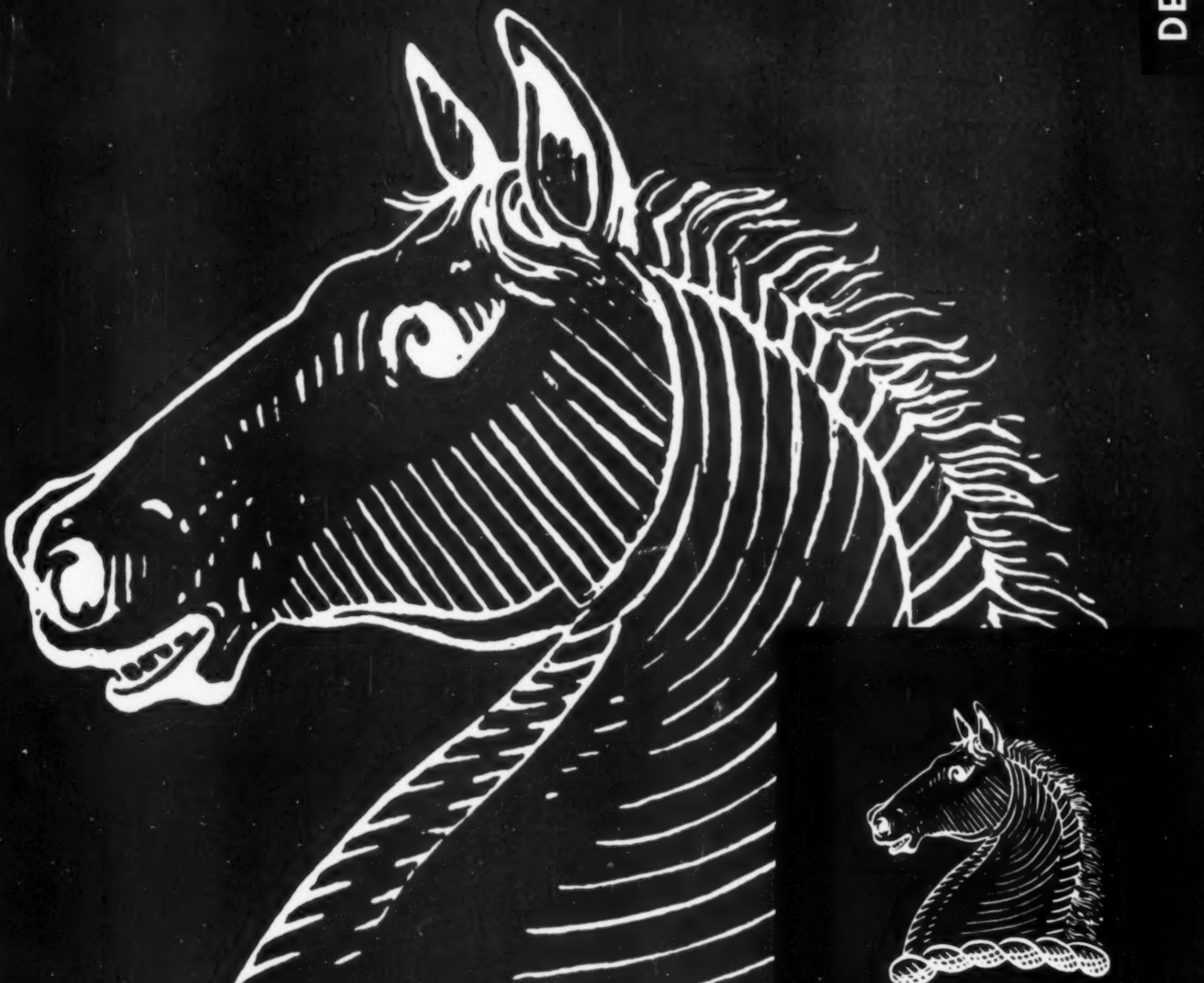
MINING engineering

DECEMBER 1953



MINING engineering

VOL. 5 NO. 12 DECEMBER, 1953

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- Journal of Petroleum Technology

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COVER

The familiar Horse Head on the cover is the trademark of The New Jersey Zinc Co. It symbolizes a company with roots going back to the founding of the zinc industry in the U. S., but which looks to the future through research, development, and exploration.

FEATURES

Personnel Service	1148	Drift	1201
Books	1167	Authors	1170
Letters to the Editor	1170	AIME News	1287
Manufacturers News	1162	Personals	1308
Reporter	1181	Coming Events	1316
Mining News	1183	Professional Services	1316
Trends	1192	Advertisers Index	1318

ARTICLES

The New Jersey Zinc Co.

The New Jersey Zinc Story 1203
Introduction—"In its 105th year" 1204
Exploration 1206

The Mines—
- Franklin-Sterling 1208
- Friedensville Development 1214
- Austinville 1216
- Ivanhoe Development 1221
- Eagle Mine 1222
- Hanover 1228

The Plants—
- Canon City 1232
- Palmerton 1233
- Depue 1251

TRANSACTIONS

The Scintillation Counter in the Search for Oil
R. W. Pringle, K. I. Roulston, G. W. Brownell, and H. T. F. Lundberg 1255

The Coal Industry in Northern Wyoming and the State of Montana
Walter J. Johnson 1262

Localization of Pyrometasomatic Ore Deposits at Johnson Camp, Arizona
Arthur Baker III 1272

Mineralization and Hydrothermal Alteration in the Hercules Mine, Burke, Idaho
Bronson Stringham, F. McIntosh Galbraith, and Garth M. Crosby 1278

Starches and Starch Products as Depressants in Amine Flotation of Iron Ore
C. S. Chang, S. R. B. Cooke, and R. O. Huch 1282

— Personnel Service —

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Paleontologist, 41, married, three children; B.S., M.A. degrees both in geology, PhD. near completion. Ten years experience nonmetals deposits and some metal deposits. One year as superintendent in Mexico; five years experience in application of microscope to evaluation of nonmetals. Desires teaching position in geology dept. preferably in the West. M-49-474-E-6-San Francisco.

Graduate Mining Engineer, 34, married, Canadian citizen, veteran. Six years experience gold, base metal, and industrial mineral mining. Experienced in development and production and Heavy-media supervision. Seeks permanent position with future. M-48.

Mine Superintendent, 38, School of Mines graduate; 13 years experience in Canada as miner, surveyor, shift boss, and assistant chief engineer. Five years in Latin America as shift boss, foreman, chief engineer, asst. supt., and mine supt. Available one month. Mexico, Central or South America. M-50.

Mining Engineer, 34, single, M.S. degree, registered P.E.; 13 years experience operation and management in hardrock and placer, including four years mine examination, western U.S., Alaska, Canada. Will go to foreign country. Available short notice. M-51-36-4710-E-5-San Francisco.

MANAGER or ASSISTANT MANAGER. Graduate, married, 3 children, age 48, 25 years varied experience in underground and open-cut mining. U. S. or foreign. Familiar with all phases of mining operations. Fluent Spanish.

Box K-25 AIME 29 W. 39th St., N.Y. 18

POSITIONS OPEN

Assistant Professor in mineral dressing with Master's degree, preferably with some experience. Salary open. Location, Pacific Northwest. Y9226S.

Mine Superintendent with 10 to 12 years underground experience for lead-zinc mine. Must speak Spanish. High altitude. Salary, $7200 a year plus housing and maintenance. Location, Peru. F9208.

Mining Engineer to examine manganese, copper, lead property. Salary open. Location, Cuba. F9164.

Junior Mining Engineer. Must have at least one years post graduate engineering experience. Starting salary for single status, $3600 a year plus room and board, plus service benefits. Two-year contract. Transportation paid. Location, Colombia, S.A. F9086.

Technical Sales Engineer for export dept., to assist in technical sales, and familiar with overseas operations and able to speak French and German. Should have mining engineering background and be familiar with heavy underground and construction machinery. Salary open. Headquarters, New York. Y8342.

Mining Engineer, young, graduate, with some experience in surveying and mapping. Should be able to assume responsibility and get along well with associates. Duties will include mine and surface surveying and mapping, calculating and performing other related engineering work. Salary to start, $4200 a year with opportunities for advancement and increase. Location, South. Y8371.

Mining Engineer and/or Geologists to go to Israel for about one or two years as consultant to the Government. Salary open. F9314.

Engineers. (a) Mine Superintendent, 32 to 38, with ten years underground experience for deep mine. Excellent camp and living conditions. Must speak Spanish. Salary, $10,000 a year. (b) Assistant Mine Mechanical Superintendent, 40 to 50, with at least ten years experience covering installation and repair of compressors, pumps, hoists, and complete mining plant. Must speak Spanish. Salary, $10,000 a year. Location, Cuba. F9140.

Placer Development Engineer, 35-50, experienced in placer examination and operation of dragline dredges, hydraulics, sluicing, high lift pumping. Experience in reservoir construction and water distribution methods also needed. To be assistant to chief engineer. Three year contract. Salary, $8500 a year, tax exempt in U.S. currency. Quarters and living allowance. Location, Ethiopia. F9129.

WANTED

Experienced designer, with proven record in development of air actuated percussive tools as used in mining and construction industries. Also junior engineers with design aptitude to enter the engineering departments. Location—New York State. Our own employees know of this insertion. Apply, listing experience in full to:

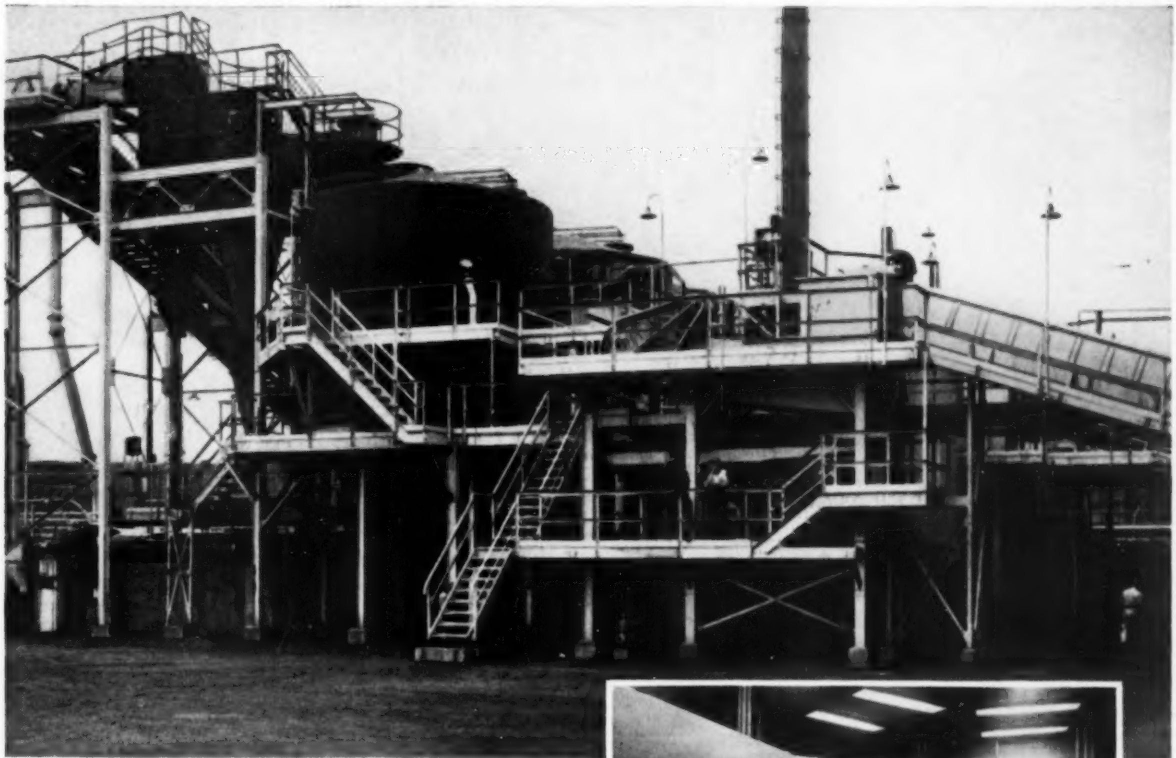
Box H-15 AIME
29 W. 39th St., New York 18, N. Y.

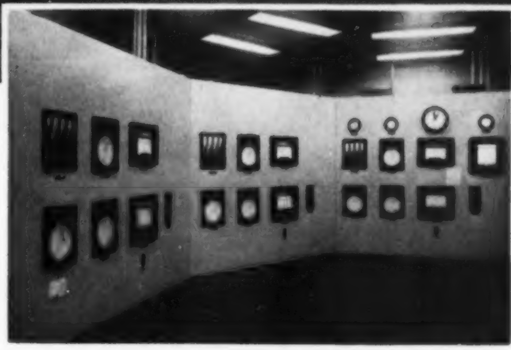
MINING ENGINEER — GEOLOGIST, 45, married, one child, excellent physical condition, 20 years' experience, 12 years in responsible operating positions, 8 years as geologist and exploration engineer. Thoroughly familiar with all types of underground mining. Excellent record for labor relations and production. Thoroughly experienced in mine examination, valuation, reports and difficult structural problems. Fluent Spanish and French. Available immediately. Location immaterial.

Box K-27 AIME
29 W. 39 St., New York 18, N. Y.

FOR SALE

One Worthington Elevator Pump, Serial #877407, 4" suction, 3" discharge, 525 lb. head, 250 GPM, 158 HP, 3670 RPM, 10" impellor, test pressure 1000 lbs., with Westinghouse reduction gear, Serial #1994, pinion RPM 3670, gear RPM 1260, normal rating 158 HP, unused. Marine Electric Co., 2121 N.W. Thurman St., Portland, Oregon, Broadway 6447.





marks new development in

EXPANSION PROGRAM

LOCATED in eastern Pennsylvania's Saucon Valley, the Friedensville project will tap large reserves of zinc ore. The main shaft, sunk to a depth of 1260 feet, has been completed. The permanent headframe is in place, the mine buildings are finished and installation of the machinery and equipment is well underway.

Compressed air for the new plant is supplied by three Ingersoll-Rand 21-inch Class PRE compressors, two of which are shown below at the left. Each unit is rated 2700 cfm, 100 psi, and is driven by a 500-hp, 180 rpm direct-connected synchronous motor.

The performance of Ingersoll-Rand equipment is well known to the New Jersey Zinc Company. For I-R stationary and portable air compressors, pumps, air hoists, pneumatic tools, Jackhamers, paving breakers, wagon drills, Jackdrills and stopers are serving throughout this vast mining operation—including the mines at Franklin, Ogdensburg, Austinville, Gilman and Hanover and the plants at Palmerton, Depue and Canon City. A few representative items of I-R equipment in use at New Jersey Zinc Company properties are shown below.

Like so many leading metal and non-metal mines throughout the world, New Jersey Zinc has found that I-R equipment can be installed with complete confidence in its ability to stand up year after year on the toughest jobs. That, of course, contributes to sustained high production—reduced operating and maintenance expense.

Ingersoll-Rand
11 Broadway, New York 4, N.Y.

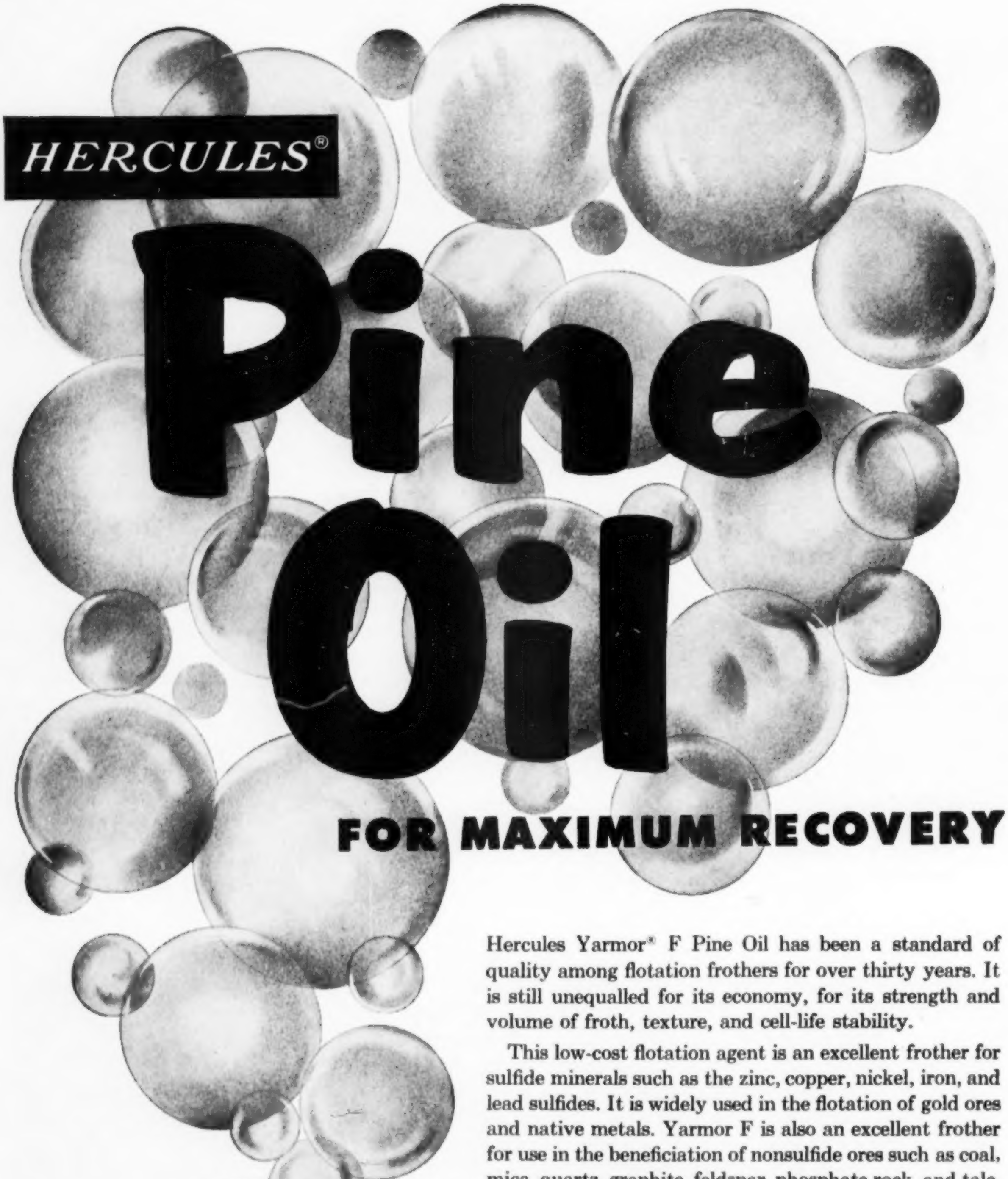
COMPRESSORS
AIR TOOLS • ROCK DRILLS
TURBO BLOWERS
CONDENSERS
CENTRIFUGAL PUMPS
DIESEL AND GAS ENGINES

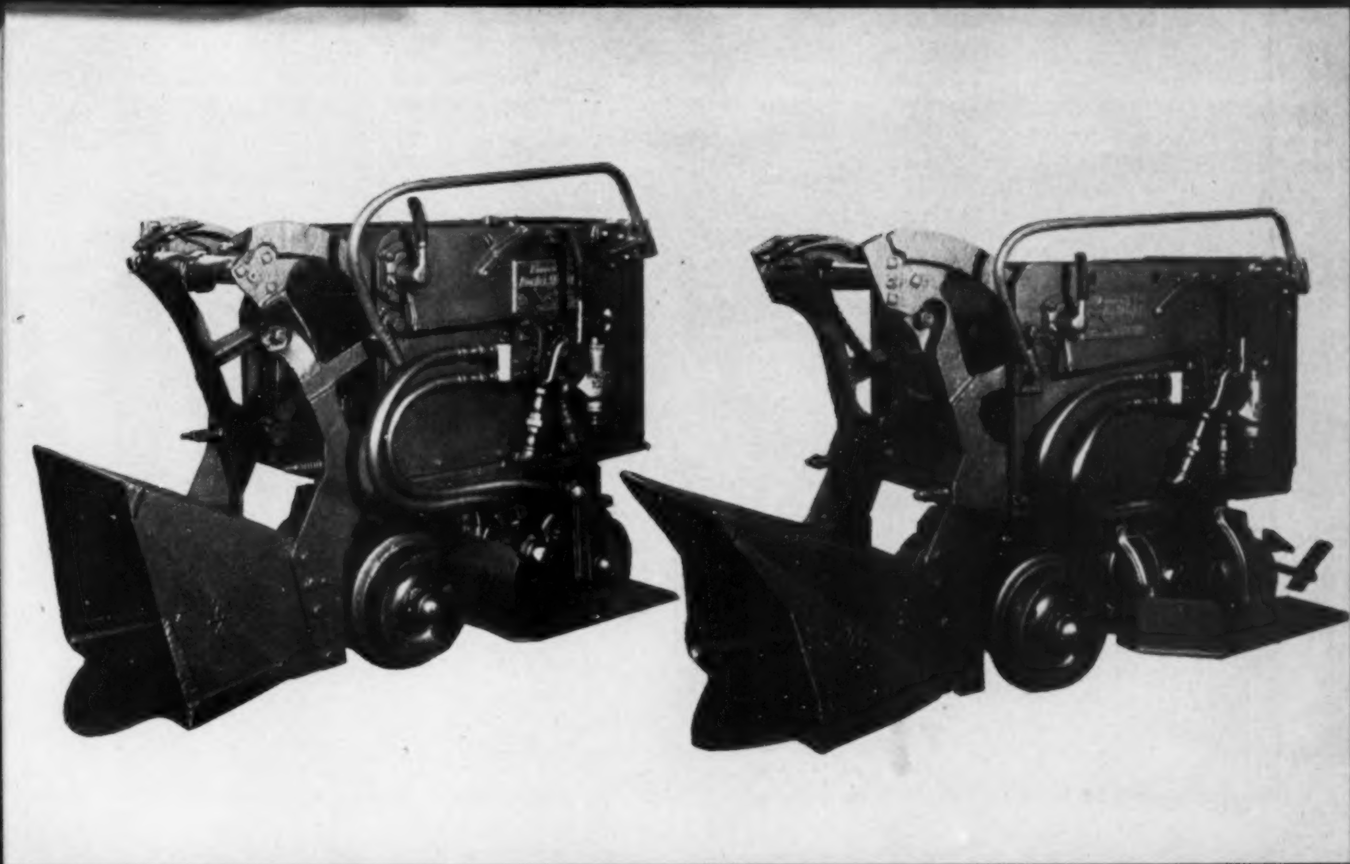
Ingersoll-Rand Model X71-WD Wagon Drill in use on open pit mining at New Jersey Zinc operations in New Mexico.

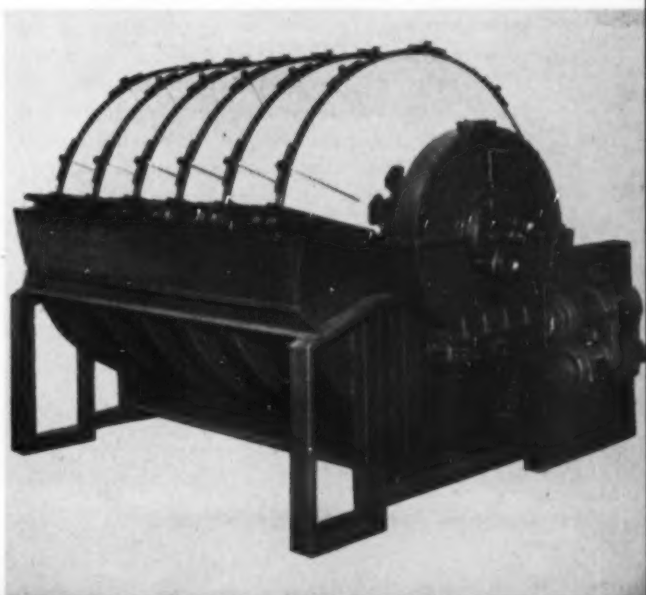
A Model JR38 Jackdrill at work in stope drilling using ⅞-inch Hexagon steel with Carset Jackbits.

Ingersoll-Rand DB30 Drifters driving a Drift heading at Hanover, New Mexico.

991-14

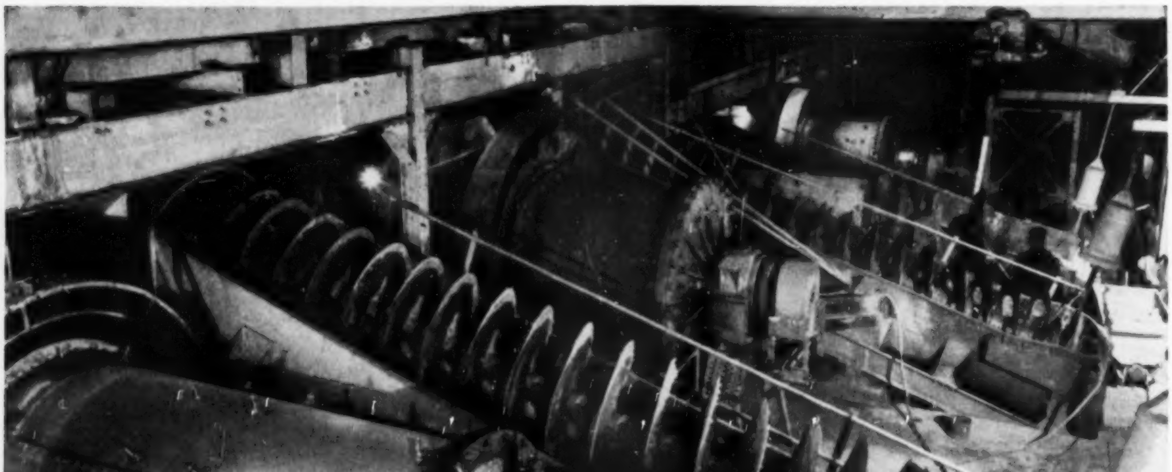




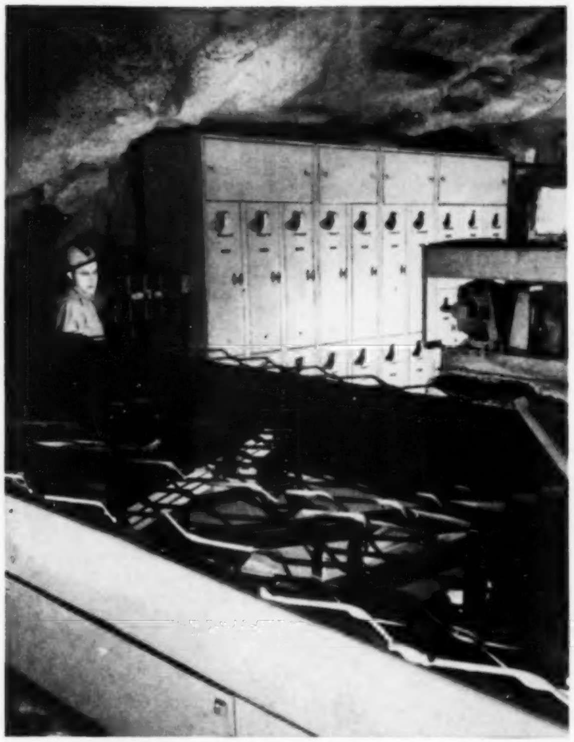


1 HAULING CARS OF LEAD-ZINC ORE up to 15° slope to the underground mill is this 72" drum hoist, driven by G-E 300-hp 440-volt motor and control. Only one of its kind, the Gilman lead and zinc mill was built entirely underground because in the mountainous terrain surrounding it there is not enough level country. Several hundred feet down, in rooms cut out of hard rock, crude ores from the adjacent mine are concentrated for smelting at distant plants.

Underground lead and zinc mill



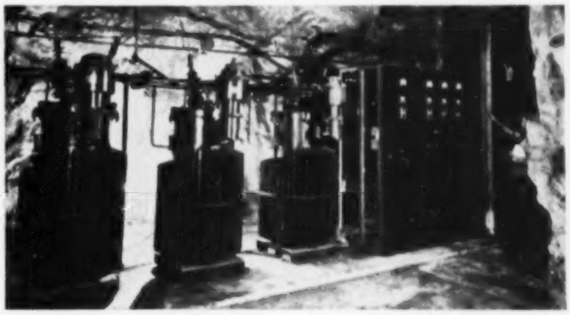
2 IN THE UNDERGROUND GRINDING ROOM, two 100-hp and two 75-hp 440-volt G-E motors and control drive grinding mills. Classifier drives consist of four 10-hp G-E motors and control. Naturally heated to 83F, water for grinding process is pumped from mine to mill by G-E induction motors.



3 GROUPED MOTOR CONTROL is provided at several points throughout the mill by compact G-E Cabinetrol† units. Space-saving Cabinetrol "packages" include all controls and instruments needed for various milling processes. This neat assembly, together with its associated push-button stations, is located in the mill's flotation cell room.

†Reg. trade mark of General Electric for enclosed control panel equipment.

4 AFTER GRINDING THE ORE, lead minerals are separated from zinc minerals and waste, and then zinc minerals are separated from waste tailings in flotation cells. Air for flotation cells is supplied by these blowers, driven by three 125-hp 440-volt G-E a-c motors, with G-E control at right.



5 POWER FOR THE MINE comes down from the surface at 13,800 volts through 4500 feet of G-E armored cable. At this substation—comprising a G-E switchboard and three 150-kva Pyranol* transformers with gas absorbers—it is stepped down to 440 volts for utilization throughout the mine's two lowest levels.

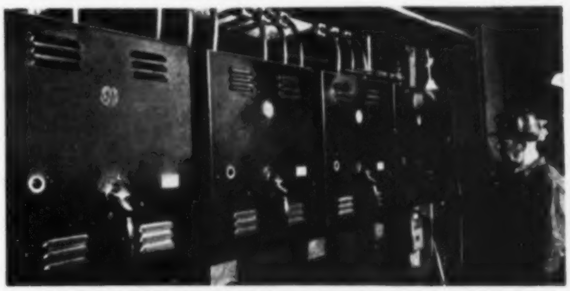
*Registered trade mark of General Electric Co. for askarel.

hits 1200 tons per day!

Co-ordinated G-E drives and distribution equipment help maintain continuity of production at New Jersey Zinc's unique Gilman, Colo. concentrating plant

You, too, can benefit from the kind of G-E application engineering that went into this installation. Call your nearby G-E Apparatus Sales Office and ask for a mining industry specialist. He'll help you solve your electrical problems in mining, concentrating, smelting and refining—efficiently, economically. Call him soon! General Electric Company, Schenectady 5, N. Y.

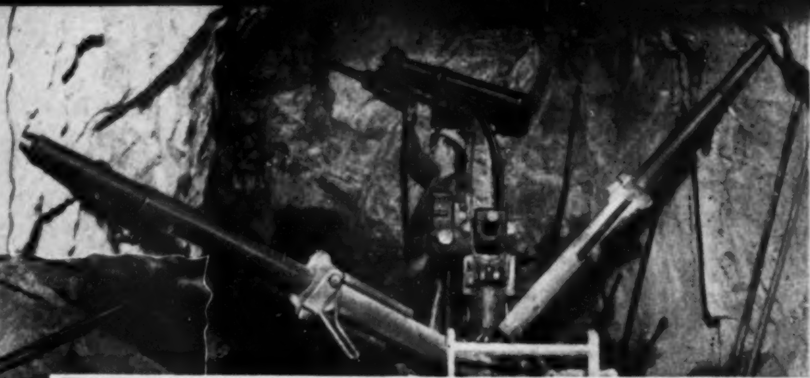
660-23



6 TO PROTECT EQUIPMENT against damage from excessive overcurrents caused by heavy overloads or short circuits, the mill uses four G-E 3-pole air circuit breakers, rated 600 amperes, 600 volts. G-E air-circuit breakers, selected for adequate interrupting capacity, help safeguard against loss of production in all milling operations.

Engineered Electrical Systems for Mining Industry

GENERAL ELECTRIC

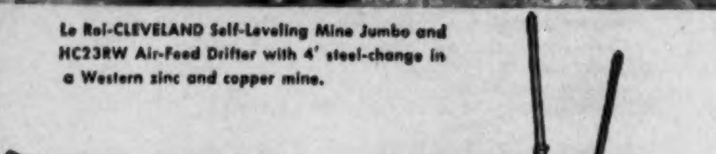


A compact Le Roi-CLEVELAND Air Motor powers the arm of this mine jumbo — miners can take it easier, yet get more done.

Le Roi-CLEVELAND Self-Leveling Mine Jumbo and HC23RW Air-Feed Drifter with 4' steel-change in a Western zinc and copper mine.

Space, Spot,

Jumbo shown is equipped with a Le Roi-CLEVELAND DR34 air feed. It is available also with HC23RW reverse air feed, or can be used with any of the Le Roi-CLEVELAND Drifters.



Le Roi-CLEVELAND MDR Jumbo

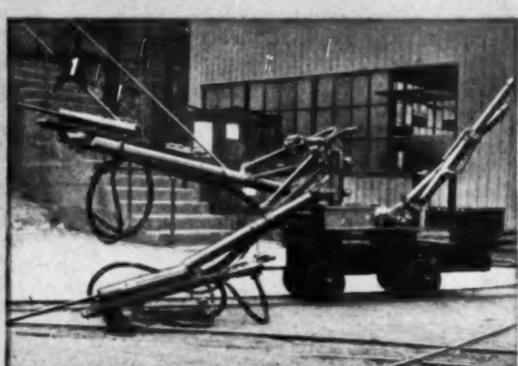
Le Roi-CLEVELAND Jumbos — equipped with air-motor-powered booms — reduce set-up time, drill out the round faster, shorten tear-down time.

To spot his drifter, the miner simply opens a conveniently located operating valve. Then a powerful, compact Le Roi Air Motor takes over, raising or lowering the boom rapidly to the desired drilling position.

What's more important, the boom stays where it's put. Drifters stay in line — there's no steel binding, no wear-and-tear on chucks. Average drilling speeds are higher.

Write for complete information.

1. Le Roi-CLEVELAND 2-Boom Jumbo with power-feed drifters about to go underground.
2. Six-drill jumbo with Le Roi-CLEVELAND power-feed drifters and air-motor booms mounted on a 1 ½-ton truck for tunnel job.
3. Le Roi-CLEVELAND Jumbo equipped with long-feed drifters for use with carbide-insert bits.
4. Air-motor-powered booms give fast, solid set-ups. It's mechanically impossible for booms to drift during the drilling operation.



and Drill Holes Faster!

Speed drilling cycles!	***Get better fragmentation!***
Save time drilling lifters!	***Speed loading cycles!***

Use a Le Roi-CLEVELAND Self-Leveling Mine Jumbo

with 4' steel-change Air-Feed Drifter

Want to get more drilling done per man-shift? Here's an easy way to go about it: Give your miners a Le Roi-CLEVELAND Self-Leveling Jumbo. It has everything they need to do the work you want — and cut your costs, too.

It has a self-leveling air-motor-powered arm. And that means miners can spot and space holes quickly and easily, for the most efficient fragmentation. They don't have to loosen a bolt or tilt a boom, to complete the drilling cycle.

It has an exclusive rigid screw and gearing mechanism that keeps the heading straight, cuts down overbreak and underbreak. It also keeps the drifters in line, prevents the steel from binding, reduces chuck wear.

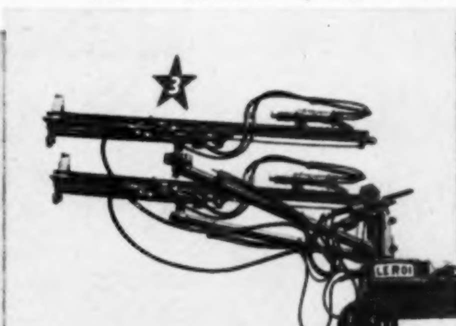
It has an offset arm that provides plenty of clearance to drill lifters. Miners don't have to take time out to swing the drill under the arm.

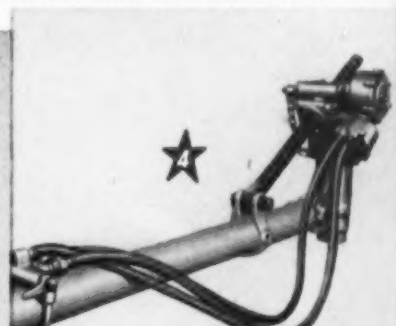
Together, these Le Roi-CLEVELAND features add up to faster cycles, greater tonnage per man-shift, lower costs! And that's why you owe it to yourself to get further information on both the single-arm and double-arm models. Write us today.

CLEVELAND ROCK DRILL DIVISION

Le Roi Company *A Subsidiary of Westinghouse Air Brake Co.*

12500 BEREA ROAD • CLEVELAND 11, OHIO *Plants: Milwaukee, Cleveland and Greenwich, Ohio*

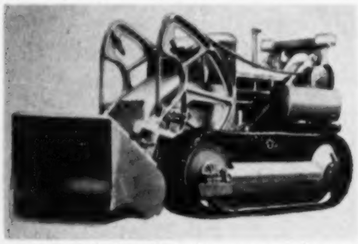




Manufacturers News

Newest Loader-Tractor

Eimco Corp. announced its entry into a new field of heavy machinery with the 105 loader weighing 34,000 lb. Leading feature is the Unidrive transmission combining torque converter, constant mesh gearing, and hydraulically operated clutches. All



gears and clutches for speed changing and full independent reversal of each track are built into one compact unit. Two handles fitting within the operator's hand provide independent control of each track—a push forward for drive, a pull for reverse, and a twist of the levers provides a spin turn for maximum maneuverability. Among other features of the new design are all steel construction, a 90-hp diesel with matched torque converter, and two speeds for the loader, which retains the Eimco rocker-arm principle. **Circle No. 1**

Plastic Pipe

Designated Carlon V, new pipe from *Carlon Products Corp.* features high resistance to chemicals. It is available in sizes from ½ to 6 in.,

and in two types: a medium impact pipe with high chemical resistance; and a high impact type with a small sacrifice in resistance. **Circle No. 2**

Bulk Products Testing

Manufacturers and users of bulk products can arrange for experiments at the testing station completed by *Atkinson Bulk Transport Co.*, Minneapolis, where facilities have been provided to determine whether bulk granular materials can be moved by the Atkinson fluidizing system. **Circle No. 3**

First Aid

Unit first aid packets from *E. D. Bullard Co.* include color coded one-use antiseptic swabs, plastic patches, and gauze dressings styled to fit the steel unit first aid kits introduced by the same company. **Circle No. 4**

Aluminum Pipe

Contractors on the West Virginia Turnpike are using aluminum pipe for lines from portable compressors to wagon drills. Portability and ease of coupling are advantages claimed for the *Alcoa* construction pipe. Both quick-disconnect and sleeve-type couplings are used to speed laying 20-ft sections of the air line. Sections weigh only 15 lb each. **Circle No. 5**

Hard-Facing

Coated tube Stoodite, new electrode for hard-facing mining, crushing, and other heavy equipment, is claimed by *Stoody Co.* to have faster deposition rate than cast electrodes,

and is readily weldable to all carbon and alloy steels. Photograph shows bucket protected on sides, lips, and teeth with new material. **Circle No. 6**

Pipe Coupling

Gruvajoints, produced by *Gustin-Bacon Mfg. Co.*, are designed to save time, weight, freight, and space in coupling grooved pipe systems operating at pressures below 500 psi. The 2, 3, and 4-in. malleable iron couplings utilize synthetic rubber gaskets said to resist deterioration by oil and chemicals. **Circle No. 7**

Drawing Instrument

Versatile drawing instrument from *Smith Drake Corp.*, called Glide-Rule, is combined triangle, T-square,

straight edge, scale, protractor, and parallel rules; in effect a pocket-size drafting machine. Reasonably priced. **Circle No. 8**

Dishwasher

A fully automatic dishwasher especially adapted for laboratory use is being introduced by *Chemical Rubber Co.* Special racks to accommodate over 90 pct of most-used laboratory glassware are a feature of the machine which is to be built by Westinghouse's electric appliances div. **Circle No. 9**

Fast 10-Tonner

Photograph shows the new 10-ton model *Dart Truck Co.* has aimed to meet demand for a fast, heavy-duty, highly maneuverable truck. Features used on the larger models are said to provide unusually rugged construction. Design on a 100-in. wheel

base provides 20-ft turning radius, and the 156 hp Continental diesel assures high speed with full load. Extra long springs in front provide easier riding and rear springs are two-stage. **Circle No. 10**

Pneumatic Tool Oiler

New oiler for air tools has patented wick filter to prevent clogging and to atomize oil. Said to operate in any position, weighing only 2½

lb in the half-pint size, the *Wright Power Saw & Tool Corp.* oiler features easily adjustable metering valve. **Circle No. 11**

Fire Rescue Suit

Featuring a lightweight of 28 lb, with pliability for ease in putting it on and for freedom of movement, a fire rescue suit from *Industrial Safety Specialties Co.* has been proven in plane crash work. Constructed with an outer layer of 90 pct asbestos cloth, 1 in. of fiber glass insulation, and an inner glass cloth steam barrier, the suit provides heat resistance up to 1800°F. An aluminized outer surface is available for work in furnaces and boilers. **Circle No. 12**

Company Announcements

Arthur D. Little Inc. has moved its Midwestern office from St. Louis to the Board of Trade Bldg., Chicago . . . The *Shafter Bearing Corp.* of Downers Grove, Ill., is now a division of *Chain Belt Co.* . . . *Caterpillar Tractor Co.* has located a new parts depot in Denver to be in operation by February.

Free Literature

(21) SPREADER: "If it is movable, the type A spreader can move it." The full type A story is told in an illustrated *O. F. Jordan Co.* bulletin.

(22) CLASSIFIER: *Western Machinery Co.'s* new bulletin contains information on wet classification principles and their application to Wemco S-H classifier design. Aimed for use in mineral dressing and coal preparation, this 20-page brochure is fully illustrated.

(23) TRANSMISSION: The latest issue of "Transmission Topics," published by the *Fuller Mfg. Co.*, covers developments in ore hauling on the Mesabi Iron Range, earth moving, and track maintenance.

(24) CRUSHERS: Seven bulletins from *Pioneer Engineering Works Inc.* describe and list the specifications on Bottom Deck Feed plants for gravel aggregates production. Plant set-ups are shown and color diagrams trace the flow of material.

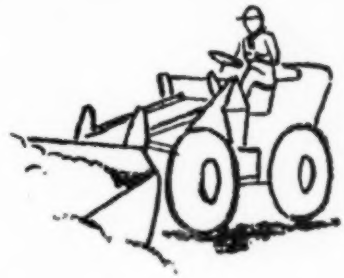
(25) GEAR LUBRICANT: For high or low temperature, for extreme pressure, Jet-Lube "OG" is a hydrous silica grease with the addition of micro-ground moly-disulphide. Complete details on this gear lubricant are available from *Jet-Lube Inc.*

(26) PUMP: *Allen-Sherman-Hoff Pump Co.'s* brochure No. 853 describes the Centriseal, a new pump designed to operate entirely without sealing water. This Maximix rubber protected unit is called the answer to pumping problems if pulp must be delivered undiluted or if sealing water is not available.

(27) GAMMA RADIOGRAPHY: "Equipment and Sources for Gamma Radiography in Industry" is the title of the new catalog from *Technical Operations Inc.*

(28) FORK TRUCK: *Elwell-Parker Electric Co.* has a 4-page brochure on its recently developed 2000-lb capacity fork truck, the electric powered Cargo Scout. Its 360° steering permits maneuvering in narrow aisles and inside truck trailers and box cars.

(29) LOADERS: Advantages of using a 3 to 1 planetary type gear reduction in each wheel of the new Baker-Lull 4-wheel drive Shoveloaders are



explained in an 8-page, 4-color brochure from *Baker-Lull Corp.* Also given are specification data on this 1½-cu yd unit.

(30) ELEVATOR BUCKETS: *Link-Belt Co.'s* 12-page book, No. 2465, covers its complete line of cast malleable and Promal elevator buckets.

(31) HOISTS: Load King hand hoists, with capacities from ½ to 2 tons, are described and illustrated in bulletin P-1254A published by *The Yale & Towne Mfg. Co.*

(32) MINING-MILLING MACHINERY: *Lake Shore Engineering Co.*, manufacturers of standard and special mining-milling machinery for every application, has information on "job-proven" mine cars and mine equipment.

(33) PULVERIZING: Information on the use of cemented carbides in wear-proofing pulverizing equipment is available in pulverizing bulletin WR-107 issued by Carboloy Dept. of *General Electric Co.*

(34) TEMPERATURE CONTROLLER: Bulletin P-811 from *Minneapolis-Honeywell Regulator Co.* covers the new 077 electronic temperature controller, with range now extended to cover −100° to +600°F. Also included are specifications and application information.

(35) OFF-THE-ROAD-TIRES: A 24-page illustrated booklet from *B. F. Goodrich Co.* shows a variety of off-the-road tires used in construction work, strip mines and quarries.

(36) PYROMETER CALIBRATION: The new tables in *Bristol Co.'s* "Pyrometer Thermocouple Calibration Data" are based on data recently released by the National Bureau of Standards. Adopted by the Scientific Apparatus Makers Assn. and the Instrument Society of America, the tables are corrected to the absolute volt and to the International Temperature Scale of 1948. The Iron-Constantan table has also been corrected to a new curve which has been adopted by SAMA.

(37) WELDING: Three bulletins on the recently developed Fillerarc consumable-electrode gas-shielded welding process are available from *General Electric Co.*

(38) FILTERS: Bulletin 4710 from *Morse Bros. Machinery Co.* contains information on Morse disk and drum filters. "Highly regarded for satisfactory performance and low maintenance," they are made in a wide range of sizes to meet almost all requirements.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

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61	Students are requested to write direct to the manufacturer.								

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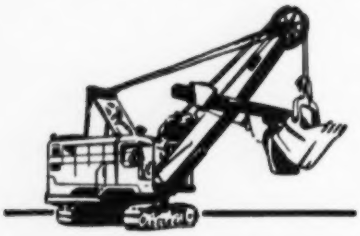
(39) KYANITE FLOTATION: The recovery of kyanite by flotation at Commercialores Inc. near Clover, S. C., is described in *Denver Equipment Co.'s* bulletin No. M4-B68, written by S. J. Beers, manager of Commercialores Inc., and H. W. Harrah, of Denver Equipment Co. Mr. Beers and Mr. Harrah begin with the geology of the kyanite formation and cover every aspect of production in detail.

(40) ELECTRIC SHOVELS: A profusely illustrated presentation from *Harnischfeger Corp.* details the specifications of P&H electric shovels to



10 cu yd capacity. Models 1055E, 1400, 1500, 1600, and 1855 are shown in color action shots. Construction details of the machines are revealed in cutaway drawings, and the workings of Magnetorque control are also outlined.

(41) FIBRES: *Continental-Diamond Fibre Co.'s* catalog GF-54 contains detailed technical data in tabular form for quick reference. For example, one page describes three sheet grades of Diamond vulcanized fibre, with available sheet sizes, thicknesses, and colors. Three fibre specialties—tubing, rods, and receptacles—are also described.

(42) BLASTING: *Atlas Powder Co.* publishes a quarterly technical bulletin to assist mine and quarry operators, construction engineers, and other users of industrial explosives. "Better Blasting" describes modern blasting techniques in a practical, readable fashion.

(43) CONTINUOUS WEIGHING: Instrumentation Data Sheet No. 10.18-3 from *Minneapolis-Honeywell Regulator Co.* deals with the Trans Weight Belt-Meter which uses an ElectroniK recorder and totalizer in the measurement of coal, ore, and other loose material on conveyors.

(44) STEEL BUILDINGS: For safer, lower-cost installations in the mining industry *Armco Drainage & Metal Products Inc.* sells easily erected steel buildings made with Steelox panels. When mines are worked out or operations have to be suspended Armco buildings can be dismantled, moved and re-erected.

(45) HARDENED BEARINGS: Zone hardened Sealmaster ball bearing units with double extended race are made by the Sealmaster Div. of *Stephens-Adamson Mfg. Co.* Bulletin 1053 explains zone hardening, a patented process that contributes to better load carrying capacity and longer fatigue life.

(46) LABELS: *Ever Ready Label Corp.* calls its 24-page catalog a "library of ideas" on the ways that labels can sell, warn, save labor, raise funds, speed deliveries, collect bills.

(47) BRUSHLESS GENERATOR: Because of the increasing interest in 400 cycle current, and the need for a convenient unit to produce it, *Georator Corp.* has developed the Nobrush frequency converter, a compact motor generator unit to convert 60 to 400 cycles. Brushes, slip rings, commutator, exciter are all eliminated in the machine.

(48) CENTRIFUGAL PUMPS: *Pennsylvania Pump & Compressor Co.'s* bulletin 237-C describes Thrustfre 2, 3, and 4-stage pumps for heads up to 650 psi, with capacities from 50 to 850 gpm. These pumps are available in both sleeve bearing and ball bearing designs for boiler feeding and general power plant and industrial use.

(49) PLANT LAYOUT: A bulletin from *Peerless Photo Products Inc.* tells how conventional plant layout procedures can be replaced with low cost plant layout system involving the use of photocopy, thus saving many man-hours of drafting.

(50) OVERLOAD RELAY: Complete engineering data, model specifications, and information on application of the hydraulic-magnetic Silic-O-Netic overload relay are provided in a bulletin from *Heinemann Electric Co.*

(51) DRILL & SCREW THREAD CHART: *Reiff & Nestor*, tap manufacturing specialists, are offering a decimal equivalent, tap drill, and screw thread chart printed on grease and dirt-resistant vinylite.

(52) HP & $$: An 8-page booklet, "Power and Profit in Construction and Mining," shows Caterpillar diesel engines and sets on the job in many parts of the world both in mining and construction. Detailed

charts in D309 show the rated hp of all Cat diesel engines and kw output of all Cat electric sets. (Copies of this booklet are also available in Spanish, French, and Portuguese by writing *Caterpillar Tractor Co.*, Peoria, Ill.)

(53) LOADERS: The Hough model HR 4-wheel drive Payloader tractor shovel is the topic of 16-page catalog from the *Frank G. Hough Co.* Action views highlight important details of this 1-cu yd machine, and pictures and detailed specifications of all seven sizes of Payloaders are included.

(54) CONVEYOR CHAIN: Duraflex, new 2½-in. pitch drop forged conveyor chain, brought out by the *Jervis B. Webb Co.* is introduced in a brochure outlining claims of strength, flexibility, easy assembly.

(55) FLOW METER: An 8-page booklet from the *Hays Corp.* tells the story of the Diaflow meter for measuring air flow, gas flow, and ratio of air to gas flow.

(56) BLACKLIGHT: Improved Blak-Ray lamps designed for use in inspection, flaw detection, control, and processing operations are described in an inspection bulletin from *Ultra-Violet Products Inc.* Replaceable lamp tubes operate 3000 to 6000 hr.

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Books for Engineers

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A Simple Guide to Modern Valency Theory, by G. I. Brown, *Longmans, Green & Co.*, $2.50, 174 pp., 1953.—In this concise, general account an outline of the structure of atoms, in which particular attention is paid to the arrangement of extra-nuclear electrons, leads to a detailed consideration of extravalent, covalent, and dative bonds. Simple treatments of resonance, the hydrogen bond, and the method of molecular orbitals are also given.

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water (Special Technical Publication, No. 130) *American Society for Testing Materials*, Philadelphia, $1.50, 54 pp., 1953.—The five papers deal with automatic sampling of industrial water; measurement of pH, electrical conductivity, etc.; continuous recording of chlorine residuals; measurement of color, turbidity, hardness, and silica; and the continuous measurement of dissolved gases.

Gold (Die Metallischen Rohstoffe, Vol. III) by Ferdinand Friedensburg, *Ferdinand Enke Verlag*, second edition, 234 pp., 1953.—Part I contains general information on occurrence and types of gold deposits, methods of mining and preparation, utilization, valuation, market conditions and price and production statistics. Part II deals with the deposits and economic significance of gold in individual countries.

Geology and Mineral Deposits of the Zosell (Emery) Mining District, Powell County, Mont., by Forbes Robertson, Memoir No. 34, *Bureau of Mines and Geology, Montana School of Mines*, $1.00, 1953.—A well-illustrated report with maps and photographs of rocks and ore specimens. Included is a list of patented mining claims showing ownership.

Elements of Heat Treatment, George M. Enos and William E. Fontaine, *John Wiley & Sons Inc.*, $5.00, 286 pp., 1953.—A simple introduction showing how the mechanical properties of metals and alloys may be altered to suit particular situations. For mechanical and design engineers, commercial plant personnel, and others who have no need to go into detailed metallurgy.

Lefax Manual of Mathematics, *Lefax Publishers*, $2.25.—Pocket-size data book containing sections on: mathematic reviews, logarithmic tables, natural trigonometric functions, conversion tables, functions of numbers. Over 334 pp. with celluloid tabbed index.

Geologic History of the Yosemite Valley, *U. S. Government Printing Office, Washington 25, D. C.*, $5.25, 137 pp., paper-bound, photographs.—Frequently used as a university text, this book is again available in a reprint to answer questions on the creation, geology, and other features of Yosemite.

Report on Studies of Stratification in Modern Sediments and in Laboratory Experiments, by Edwin D. McKee, *Arizona Geological Society*, $1.00, 61 pp.—A record by a member of the Office of Naval Research on the types of stratification as found today in beaches, dunes, alluvial fans, lagoons, and tidal flats. Twelve tables, 12 photographs, 28 text figures.

The Canadian Trade Index, *Canadian Manufacturers' Assn.*, Toronto, approx. $7.50, 1170 pp., 1953.—Essential details of some 10,000 Canadian manufacturing firms; classified directory of products; cross-reference index in French; for Latin-American trade limited editions with Spanish and Portuguese indexes; information on export trade practices, government services, etc. This new edition also has an illustrated section devoted to recent industrial development in Canada.

Handbook of Accident Prevention, for Business and Industry, *National Safety Council*, $3.00, 93 pp., 1953.—A condensed safety guide to be used as a reference for part-time safety men in small independent or branch organizations, and for use in broadening key personnel's understanding of safety in larger organizations.

Reviews of Research on Arid Zone Hydrology, *United Nations Educational, Scientific and Cultural Organisation*, available Columbia University, $5.00, 212 pp., 1953.—Official reports on eight major arid zones of the world covering underground water, hydrology and fluid mechanics, and problems of surface and ground water supply. Existing projects are reviewed and suggestions are made for further projects for research and development.

Handling Methods and Equipment in the United States, *Organisation for European Economic Cooperation*, approx. $2.00, 160 pp.—After visiting the U. S. in May and June 1951, European experts report on the means to increase productivity through analysis of handling problems, through study of application and construction of handling equipment, and through fostering a "mechanical handling spirit."

Please Order the Publications Listed Below from the Publishers

Geologic Aspects of Radio Wave Transmission, *Illinois State Geological Survey*, 121 Natural Resources Bldg., University of Illinois Campus, Urbana, Ill., 73 pp., 25¢ (One copy free of charge to Illinois residents.) 1953.—A report that "evaluates the use of field intensity measurements as an aid in geologic exploration and offers a new concept of the methods of transmission of radio waves through earth materials."

Bibliography and Index of Literature on Uranium and Thorium and Radioactive Occurrences in the United States, Part 2: California, Idaho, Montana, Oregon, Washington, and Wyoming, by Margaret Cooper, Div. of Raw Materials, U. S. Atomic Energy Commission.—A 69-page bibliography that may prove helpful to both geologists and laymen interested in uranium prospects. Available for 25¢ from *The Geological Society of America*, 419 West 117th St., New York 27, N. Y. **(Part 1: Arizona, Nevada, and New Mexico** is still available for 25¢.)

Petrographic Study of Southeastern Kansas Coals, by William W. Hambleton, Bul. 102, Part 1, 10¢, 76 pp., 5 fig., 12 pl., May 1953. **A Spiny Aptychus from the Cretaceous of Kansas,** by Alfred G. Fischer and Robert O. Fay, Bul. 102, Part 2, 10¢, 16 pp., 1 fig., 2 pl., June 1953. *The University of Kansas, State Geological Survey of Kansas*, Lawrence, Kans.

Rosamond Uranium Prospect, Kern County, California, by George W. Walker, *California Dept. of Natural Resources*, Div. of Mines, Ferry Bldg., San Francisco 11, Special Report 37, 25¢, 8 pp., 5 fig., 1953.

Field Conference Guidebook No. 6, Ordovician Stratigraphy, and the Physiography of Part of Southeastern Indiana, 50¢. **Circular No. 2, An Introduction to the Geology of Parke County, Ind.,** free. **County Base Maps** (scale: 1 in. equals 1 mile): No. 11 (rev.), Clay County; No. 28 (rev.), Greene County; No. 39, Jefferson County; No. 51 (rev.), Martin County; No. 60 (rev.), Owen County; No. 61 (rev.), Parke County; No. 67 (rev.), Putnam County; No. 83 (rev.), Vermillion County. Section, township, and range lines, incorporated towns and cities, major streams, and land grants and donations are shown. 50¢ each. Publications Office, *Geological Survey, Indiana Dept. of Conservation*, Bloomington, Ind.

Geology of the Santa Rosa Lead Mine, Inyo County, Calif., by Edward M. Mackevett, *California Dept. of Natural Resources*, Div. of Mines, Ferry Bldg., San Francisco 11, Special Report 34, 50¢, 9 pp., 2 pl., 3 fig., May 1953.

Storage Battery Technical Service Manual, *The Assn. of American Battery Mfgrs.*, 2706 First National Tower, Akron, Ohio, 30¢, 44 pp., 1953.—First issued in 1943, this revised manual is in its third edition.

Meet The Authors

Bronson Stringham (p. 1278) is chairman of the dept. of mineralogy, University of Utah. This is his first paper in AIME *Transactions*. Born in Salt Lake City, Mr. Bronson earned a Bachelor of Science and Ph. D. after completing work at the University of Utah, and New York City's Columbia University. He became an instructor at the University of Utah in 1937. After a period with the Geological Survey he was made a full professor at the University of Utah in 1948. He is a member of Sigma Nu and Sigma Xi.

Arthur Baker, III, (p. 1272) is a resident of Johnson Camp, Dragoon, Ariz., where he is associated with the Coronado Copper & Zinc Co. A Junior member of the AIME, this is his first paper published by the Institute. After graduation from Wesleyan University, Middletown, Conn., Mr. Baker studied at Stanford University, where he earned a Master's and a Ph.D. He once spent three months as an exploration geologist with the West Shasta Exploration Co., in northern California. Mr. Baker has now been with Coronado for more than three years as a mine and district exploration geologist. Among his interests are reading, hunting, and traveling, the last preferably in the back country.

Garth Crosby (p. 1278) earned his Bachelor of Geological Engineering from the School of Mines, University of Minnesota, at Minneapolis in 1942. He is a member of Sigma Gamma Epsilon, honorary geology, mining, and metallurgical fraternity. He was a geologist with Alloy Metals Co., N. Mex.; and is now senior geologist in charge of Day Mines geology dept. He is a member of a committee for the Boy Scouts, Idaho Panhandle Council. Mr. Crosby is also interested in church work and is a member of the Wallace Congregational Church. When he can, Mr. Crosby likes to take to the fairways.

—Letter to the Editor—

Highest and Deepest

In the October issue of MINING ENGINEERING (p. 963) a picture of the Coleman Collieries' mine carried a caption that its altitude of 7400 ft gives it the claim of being the highest coal mine in the world.

While Cerro de Pasco does not wish to claim the distinction of operating the world's highest coal mine, I would like to point out that operations at the Goyllarisquisga mine are carried out at an altitude of about 13,000 ft and the Jatunhuasi mine, which went into production early this year, operates at an altitude of about 14,700 ft.

F. N. Spencer, Jr.
Resident Mining Engineer
Cerro de Pasco Corp.
New York City.

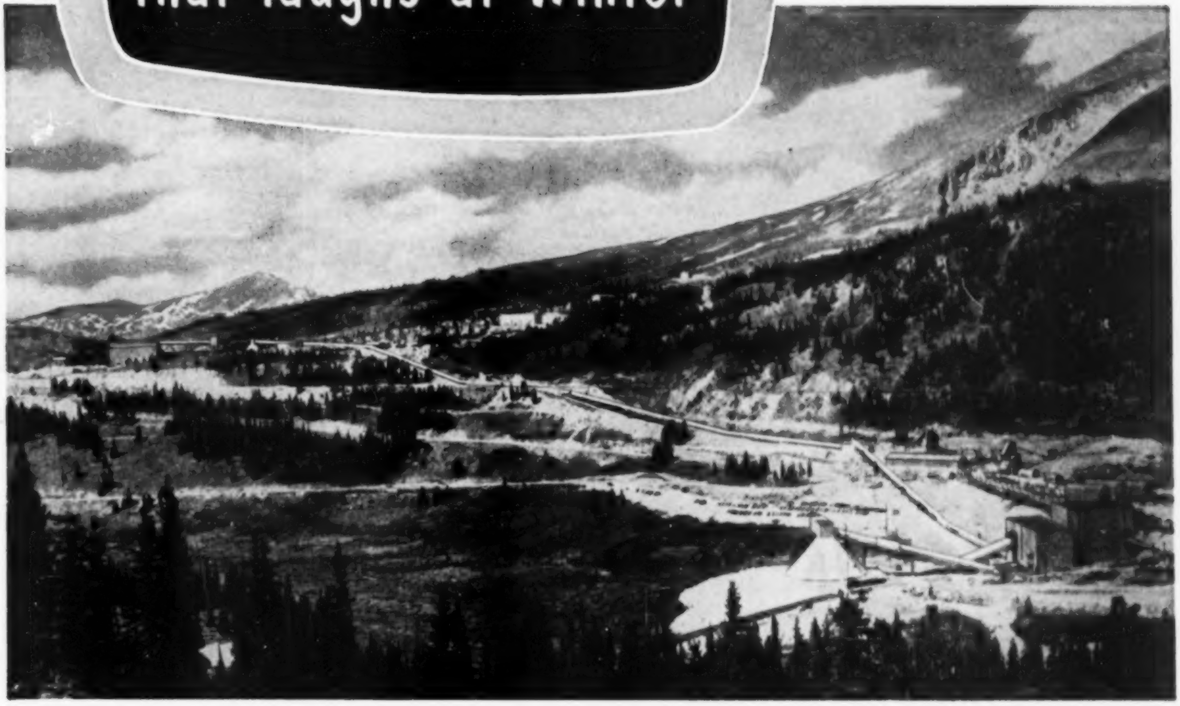
While the editors are aware that 7400 ft is not high altitude as far as mining goes, it is a bit unusual for a coal mine. As a matter of fact MINING ENGINEERING *has recently been assembling information as to the deepest shafts and longest drill holes.*

According to the figures at hand the deepest "hole" is the Ohio Oil Co.'s A-74-2 in the Paloma field, Kern County, Calif. This well passed the previous world record and on October 6, 1953 reached 21,482 ft, 362 ft beyond the 4-mile mark.

According to a paper read at an AIME annual meeting, the world's deepest diamond drill hole was drilled near Johannesburg, South Africa, in 1936 and 1937. This hole reached 10,718 ft.

Does anyone have recent figures on the deepest operating mine shafts of the various continents?—Editor.

A rubber railroad that laughs at Winter



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IRON MOUNTAIN MICHIGAN

The New Jersey Zinc Co. announced purchase of a mining property in Mineral, Va., 48 miles northwest of Richmond, Va. Known as the Arminius mine, it has been inactive for nearly 30 years. Diamond drilling has been under way and the mine will be unwatered and exploration continued at depth.

Wah Chang Corp. fired two new furnaces of a total of six at its Glen Cove, L. I., tungsten refinery during ceremonies attended by top Government officials. Wah Chang expects to use only one furnace at this time. Full capacity is expected to be employed only in the event of war.

Uganda Development Corp. announced that it has completed arrangements with Colonial Development Corp. and Frobisher Ltd. for funds to bring the Kilembe copper mine in western Uganda into production. Plans call for a mining rate of 40,000 tons of ore per month. Copper concentrate and cobalt pyrite concentrate will be produced.

Diamond drilling has been completed on International Minerals & Chemical Corp.'s feldspar reserves in southern Connecticut. Plans are being drawn for a feldspar plant which will probably use the LeBaron-Lawver dry beneficiation process. International is also diamond drilling at its nepheline syenite properties in southern Ontario. A mill to process this material is expected to be in operation at Blue Mountain, Ont., by mid-1954.

United States Smelting Refining & Mining Co. closed its mining and milling operations at Bayard, N. Mex. Low prices and high costs were given as the reason for the move.

First load of concentrate from the Sherrit Gordon mine at Lynn Lake, Manitoba, was recently shipped. Production started two years after the Sherridon plant was shut down and started moving 150 miles north by tractor. Plant capacity is expected to reach 2000 tons after the first of the year. The nickel-copper orebody was discovered in 1941.

Direct U. S. investments in Canada reached almost to the $5 billion mark by mid-1953, according to the Office of Business Economics, U. S. Dept. of Commerce. The annual rate of growth has been more than $500 million since 1950. Investment in mining and smelting ranked third in 1950 for about $334 million.

Australia's Prime Minister, R. G. Menzies, warned in a recent speech that Australia has a long way to go before she becomes a significant uranium producer. He added that there is also no certainty that a great deal of uranium will be found. A long lag is expected between discovery and sale of the product, with an outlay of millions of pounds probably involved.

U. S. Cancels Pact With Westmoreland

Edmund F. Mansure, General Services administrator, announced cancellation of a contract with Westmoreland Manganese Corp. of Batesville, Ark., "because of default by Westmoreland in failing to comply with the terms of the agreement."

Signed April 1952, the contract called for production of 264,000 tons of processed manganese ore within six years after production started, or by June 30, 1959. The Government agreed to advance $3,807,250 against production for construction, equipment, and completion of land purchases. The advance called for 4 pct interest on the unpaid balance. At time of contract cancellation the Government had loaned Westmoreland $2.8 million. According to Mr. Mansure, no ore had been delivered and facilities called for by the contract had not been completed.

A registered letter to M. F. Highsmith, company president, stated, in part, ". . . . You will please grant the Government immediate possession of the facilities and properties covered by the mortgage securing advances heretofore made."

Mr. Mansure stated that the contract between Westmoreland and the Government had been amended last April so that foreclosure could take place at anytime. "This was done because at that time the financial position of the company appeared to be such that foreclosure might become a necessity—which it now has," Mr. Mansure said.

Algoma Starts Long Range Development Program

Algoma Ore Properties, Ontario mining company, is beginning expansion program expected to result in 50 million tons of iron ore over the next 20 years, according to Sir James Dunn, president. Preparations are going ahead for getting a 900-ft deep block of the ore zone in the Helen, Victoria, and Alexander mines ready to take over full scale production in four or five years when present operating levels above are exhausted. A shaft will be sunk to 2000 ft, in addition to sinking an inclined winze for preliminary development from the bottom of the present workings, and driving a 5000-ft inclined tunnel. A continuous tramway from the loading stations underground to the sinter plant will be installed in the tunnel. The shortest tram haul will be 15,000 ft and the longest 20,000 ft.

The winze from the present bottom level will help in development of the ore zone at the three new levels. Stope preparation, it is hoped, will be well advanced by the time the new shaft and tunnel are completed. Increase in operating costs expected from the greater depth will be overcome, in part at least, by improvements in mining practice and ore handling.

The program is the largest major development attempted in the history of the Helen mine since it began production as an open pit in 1939. The new No. 5 shaft will be 2600 ft southwest of the present operating shaft, No. 3, or at the southwest end of the Helen orebody. The tramway tunnel is expected to be 12x12 ft and at a 22° incline. Three-ton buckets will operate underground on rails in a continuous flow, and on cables at the surface.

Cat D4 crawler tractor and HT4 Traxcavator load lead and zinc ore into W10 Wagon drawn by Caterpillar DW10 diesel tractor. Machines have been equipped with exhaust scrubbers, making them suitable for underground operations.

More High Grade Ore Revealed at Errington

Deep diamond drilling reveals ore a half mile below the outcrop has a width almost 50 pct greater than that of the ore in the original Errington open pit, according to M. S. Fotheringham, president of Steep Rock Iron Mines Ltd.

Drilling is being conducted from Errington underground workings. "The ore is the same high quality produced from open pit mining. This is the greatest depth on the Steep Rock range yet explored by drilling and confirms the views of our geologists that the ore persists to extreme depths," Mr. Fotheringham said.

Steep Rock shipped the first ore from the Errington pit in 1944. During 1953 ore was shipped for the first time from underground facilities and from a new open pit, the Hogarth mine. Hogarth production has averaged more than 10,000 tons per day, with a high of 16,123 tons.

Underground operations at Errington are in ore on three levels. Volume production is expected by year's end. The shaft has been sunk to 1250 ft.

Ask FOA Assistance For Kenya Deposits

London and Washington talks between members of the Foreign Operations Administation and the Kenya Minister for Commerce and Industry have resulted in agreement that certain Kenya ores are interesting enough to justify FOA assistance.

FOA will determine best methods of ore treatment. Application for assistance will be made through regular channels. Deposits in question are near the coast of Mrima Hill, south of Mombasa.

American technical assistance in mining was given by geologists sent to the Crown Colony about three years ago under the Economic Cooperation Administration, forerunner of FOA.

Participating in the recent conversations were Lincoln Gordon, FOA London mission chief; William Rand, deputy director of FOA in Washington; Mr. Moran, head of the African section; and Mr. Hope-Jones, member for Commerce and Industry in the Kenya government.

DMEA Makes Changes In Aid Regulations

Regulations under which the Government, through Defense Minerals Exploration Administration, will continue to finance the cost of exploration for new deposits of strategic minerals have been amended again.

The program will now be restricted to minerals in short supply for defense needs. Government participation in the aproved costs of any exploration project has been reduced from 90 to 75 pct, according to Interior Secretary Douglas McKay.

Government assistance is available for the following minerals and metals:

GROUP A: Chromium, copper, and molybdenum. The Government will contribute 50 pct of the approved project costs.

GROUP B: Asbestos (chrysotile only), beryl, cobalt, columbium, manganese, mica (muscovite block and film only), nickel, platinum, tantalum, tungsten, and uranium. The Government will contribute 75 pct of the approved costs.

All applications of record on the date of publication of Amendment 3 to DMEA Order-1 will be processed in accordance with criteria previously in effect, and reduction in percentage of Government participation for all metals and minerals listed under Group B will apply only to applications received after Nov. 3, 1953.

President Appoints Minerals Policy Group

President Eisenhower appointed a four-man cabinet committee instructed to develop a minerals policy for the U. S., and to make recommendations by Mar. 31, 1954.

The committee is composed of Interior Secretary Douglas McKay, Secretary of State John Foster Dulles, Commerce Secretary Sinclair Weeks, and ODM Director Flemming. Mr. McKay will serve as chairman.

In a letter to Secretary McKay, President Eisenhower said, "... depressed conditions within numerous metal mining districts" are "a matter of grave national concern. The mining industry has contributed in a large measure to our present state of preparedness through the vigorous expansion of its facilities. Every effort should be made to preserve this new added economic strength through policies that will be consistent with our national and international policies."

Prior to the appointment of the committee, Secretary McKay indicated that the Administration be-

lieves the U. S. should be less dependent upon foreign sources for critical metals and minerals. He said that it would be the policy of his department to establish a "going concern" mining industry in this nation. His department intends to emphasize trade in metals and minerals with the nations of the Western Hemisphere.

At the same time Mr. McKay said that in periods of emergency the U. S. must get scarce materials from any nation that has them.

Engineering Research Unit Starts at Tulane

Rufus C. Harris, president of Tulane University, New Orleans, announced formation of an Engineering Research Institute on the school's campus to serve the needs of expanding industry in the area.

Raymond V. Bailey, head of the department of chemical engineering, was named head of the institute, to work under the general supervision of Lee H. Johnson, dean of the school of engineering.

"There are innumerable engineering problems needing investigation in this area," Mr. Bailey said. "More efficient methods are constantly being sought in the chemical, petroleum, sulphur and other industries centered in the vicinity."

The Institute will offer research services in more than 20 specialized fields such as fluid flow, heat transmission, analog computation, electronics, prestressed concrete, stream pollution, illumination, metallurgy, and others.

Retake Burma Mines

The British-owned Mawchi tungsten mines in Burma were found in good shape when troops recaptured them from insurgent forces. Telephone exchange and two hydro-electric power stations were also in good order.

Goldfield Closes Washington Mill

Goldfield Consolidated Mines, a Reno, Nev., company, has closed its mill at Colville, Wash., because of low lead and zinc prices, according to T. Higginbotham, general manager.

Located 25 miles north of Colville, the mill has a capacity of 350 tons per day. Goldfield suspended operations at its Anderson open pit mine when lead and zinc prices dropped a year ago, but continued to operate the Deep Creek mine near Colville. Part of the Deep Creek mine crew will be kept on for development work. Goldfield is one of several companies which either suspended or curtailed operations in the Coeur d'Alene district of northern Idaho.

Orinoco To Ship 2 Million Tons in 1954

In February 1950 MINING ENGINEERING published the first story on the exploration and discovery of Orinoco Mining Co.'s Cerro Bolivar iron mine. Since then, the U. S. Steel Corp. subsidiary has made rapid strides toward development. Two million tons of iron ore will reach U. S. ports in 1954, according to U. S. Steel spokesmen.

Three men who had a lot to do with discovery and development of Orinoco Mining Co.'s Cerro Bolivar mine stand on the iron-rich hill in Venezuela. They are, from left to right: F. H. Kihlstedt, who was chief engineer of the exploration; Forbes Cronk, chief mining engineer (retired) Oliver Iron Mining Co; and Mack C. Lake, chief of the exploration and now president of Orinoco.

Early in 1954 the first shipments of Orinoco Mining Co. ore from Cerro Bolivar will start toward U. S. ports. It will be the culmination of engineering achievements which resulted from discoveries by F. H. Kihlstedt, Orinoco mining engineer, who struggled up the steep northern slope of a hill called La Parida, in Venezuela.

La Parida today is Cerro Bolivar, from which Orinoco, a U. S. Steel Corp. subsidiary, expects to ship about 2 million tons of ore in 1954. Output is expected to reach a 5 million ton annual rate by the end of the year.

Kihlstedt saw ore exposed in lavish masses by slides as high as 200 ft. Average grade of the ore by dry analysis is about 63.50 pct iron. Natural iron content is calculated to be 58 pct. According to W. W. Wanamaker, chief engineer of Orinoco, "The iron ore is practically free of sulphur and other objectionable elements" and "is a mixture of hematite, limonite, and a small percentage of magnetite."

Cerro Bolivar is 88 miles from the junction of the Caroni and Orinoco Rivers, which in turn is 154 nautical miles from tidewater. From the mouth of the Cano Macareo, or tidewater, it is 2004 nautical miles to the Fairless works at Morrisville, Pa., and 2135 miles to Mobile.

Ore at Cerro Bolivar is practically free of overburden, according to Mr. Wanamaker, who recently spoke at the annual meeting of the American Society of Civil Engineers. Power shovels will mine the ore which in some ways can be likened to an outer shell of the mountain. Trucks will take the ore to railroad cars waiting at the top of the hill. A single track railroad runs from the top of the mountain to Puerto Ordaz, junction of the Orinoco and the Caroni Rivers. At the port ore will be transferred from rail cars by a car dumper and pass through crushers to a belt conveyor system for delivery to stockpile. A reclaiming system will remove ore from the stockpile and load it directly into ocean going vessels at dockside.

Cerro Bolivar, as it looked to the men who first saw it and clambered up its sides to discover one of the richest iron ore strikes in recent times.

Shovel capacity of two 8-cu yd Bucyrus-Erie 190B electric shovels and one 6-cu yd Lima diesel powered shovel is considered ample by Mr. Wanamaker to produce 5 million long tons annually on a single shift basis. Shovels will operate initially in three localities on 50-ft benches at the top of Cerro Bolivar and near its western end.

Drilling will be with Type 50-T Bucyrus-Erie churn drills and Joy type 58-BH rotary drills with 7⅜-in. hole. In the development stage, it is expected that jack hammers, Joy DM-10 or DM-4 Drillmobiles with 4-in. diam bore and heavy wagon drills, will be employed.

Sixteen 20-cu yd Mack trucks, type LRSW will be used to haul ore to two structural steel loading docks about a half mile from mining operations. Ore will be dumped from the docks into rail cars.

Towns are under construction at the mine and port. Houses for general workers provide 700 sq ft per unit. Detached houses for white collar workers are from 1045 to 1285 sq ft in floor area. Staff houses contain from 1400 to 1630 sq ft. All buildings are concrete block, single story, with flat concrete roofs.

Wherever possible, local materials were used. All cement, petroleum products, and most of the lumber, tools, and minor supplies were

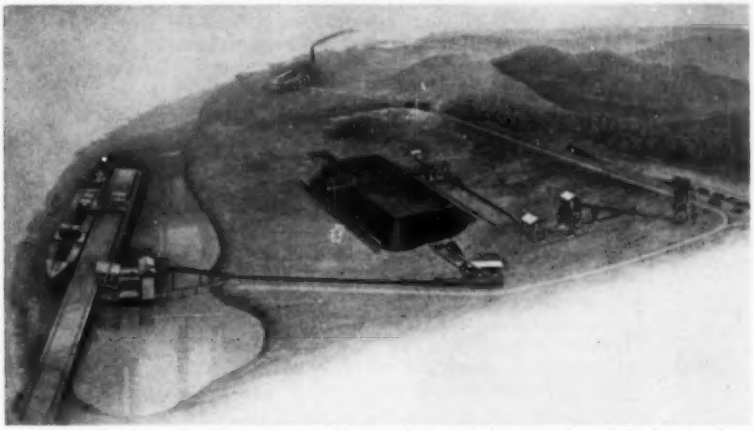
bought from Venezuelan sources. Some 30 Venezuelan firms received prime contracts and many of these entered into subcontracts with other Venezuelan contractors.

An important part of the Orinoco operation was the dredging of a channel from Puerto Ordaz to the sea. The channel provides a 26 ft depth at low tide and 250 ft width, widening to 400 ft at the mouth.

Length of the deposit at Cerro Bolivar is about 4 miles, it has a maximum width of about 4000 ft and an average ore thickness of about 230 ft. Maximum proven thickness is about 550 ft. The deposit consists of extremely closely folded ore layers and associated ferruginous quartzite. Expansion to 10 million tons annually if necessary is possible, according to Mr. Wanamaker.

This is one of the 16 Mack LRSW off-highway dump trucks that will be used to haul ore from the mine to the railhead at Cerro Bolivar.

Ore Handling System at Puerto Ordaz



Puerto Ordaz ore handling system is illustrated via artist's conception of the layout. It will be in operation soon, handling 67 ore cars per hr. Initial stockpile capacity is 700,000 tons.

Only one crusher is being installed at Puerto Ordaz. Dumping cycle and apron feeder are adjusted to provide a capacity of 3000 tons per hr, although all components are designed to handle as much as 6000 tons per hr to meet ultimate requirements of mining and shipping, according to L. O. Millard, of Link-Belt Co., designers of the ore handling system. Locating the crusher at Puerto Ordaz will make it possible in the future to handle ore from mines other than Cerro Bolivar.

Ore is delivered to Puerto Ordaz in 90-ton rail cars which are uncoupled upon arrival and allowed to drift individually into a conventional retarder. A rotary dumper, designed and built by Wellman Engineering Co., discharges 67 cars per hr. Loaded cars bump preceding cars from the dumper. All barney and dumper operations are electrically interlocked and controlled by one operator.

Ore is discharged into a scalping grizzly with 9-in. openings. Oversize goes to a stone box above an Allis-Chalmers 60-in. gyratory crusher. Undersize from the grizzly joins the −9 in. crushed ore beneath the crusher. According to Mr. Millard, tests indicate that ore will rarely contain more than 50 pct oversize. More than 50 pct limits the capacity that can be fed to the system.

One feeder withdraws combined grizzly undersize and the crusher product from a common outlet. In addition to providing a uniform feed to the conveyor system, mixing crushed ore with sticky ores that pass through the grizzly promotes flowability and reduces tendency to bridge over the feed opening. The feeder is a steel apron type designed with extremely massive construction to withstand punishment.

A system of 60-in. conveyors operating at 600 fpm transfers ore from primary to secondary crushing, and then to storage.

Main inclined conveyor No. 2, from primary to secondary crushing, is driven by a 1250-hp motor. At the secondary crushing plant, −9 in. ore is discharged into a surge and distribution chute which feeds four scalping screens ahead of crushers. Oversize from these screens is delivered to opposite sides of the crusher stone boxes for more effective crushing. The final product emerges from the secondary crushing plant. Eighty-five pct of the final product will pass 5 in. and maximum capacity is based on not more than 40 pct of +5 material passing to the two 30x70-in. gyratory crushers designed for secondary service.

Location of conveyors from secondary crushing to storage, as well as the use of a bridge for orebedding, was dictated by space limitations and topography. Area available for the 700,000-ton initial pile was relatively narrow. It was also too short to contain the proposed future tonnages in the multiplicity of piles used with other ground storage arrangements. The bridge provided maximum volume.

"The 60-in. wide belt conveyor alongside the pile delivers to bridge belt conveyor by means of a special high tripper which is propelled by the bridge through a draw bar. The bridge itself has a span of 400 ft," Mr. Millard states.

Practically every condition common to Duluth or Superior contrasts with those at Puerto Ordaz, except that ore handling from stockpile to ship must be fast and dependable. It must be able to service ocean going ore carriers of every type, including those yet to be built.

A belt system for transporting ore from stockpile to ship presented no mechanical complications, and tunnel conveyors were chosen to provide economical reclaiming. To compensate for any sticky ore encountered, it was decided to employ a traveling rotary plow type feeder to assure ore flow through tunnel openings. Ore from the two 48-in. wide tunnel belts is transported by a system of 60-in. wide belts to the traveling shiploader.

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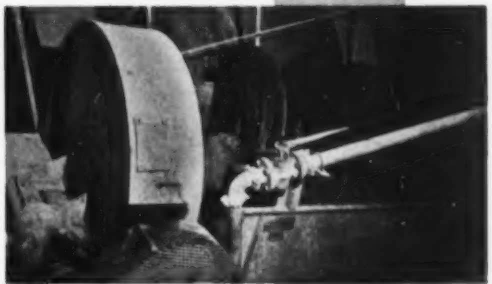
obtains efficient performance from WEMCO S-H CLASSIFIERS

At the Austinville, Virginia, plant of The New Jersey Zinc Company, Wemco S-H Classifiers are being profitably used for wet classification control of the grind. Used in the primary grinding circuit, these Wemco units have proven efficient and economical in this producer's closed circuit grinding operations.



78" Wemco S-H Classifier operating in closed circuit with grinding mill at The New Jersey Zinc Company.

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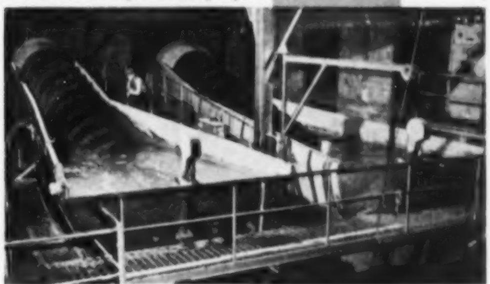

Typical installation of Wemco S-H Classifiers in a closed grinding circuit.

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Up to 40% greater shaft strength — large diameter tubular shaft gives maximum protection against shutdowns.

Long-life wearing shoes — of tough, thick alloy with large cross-section; cuts replacement costs to as low as 4/100 of 1 cent per ton of sand raked.

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THERE appears to be little doubt that the U. S. is going through a period of economic adjustment. Foresight and hindsight indicate that some leveling off from the high of last spring is inevitable. While an exact assay of the situation is impossible, many conservative economists are attempting to evaluate the economic future on the basis of solid past experience. Economists are usually the first to emphasize that economics is at best an inexact science. Yet, when employed properly and judiciously, it offers at least a rough idea of what may happen.

According to the economic research dept. of the Chase National Bank, adjustments in the economy have thus far been taken in stride. "Impressive elements of strength underlie current business activity." Chase economists say that while production is down 4 pct from the peak of last March, soft goods output is "on a high plateau." However, while some hard goods markets show signs of moderate easing "basic demand is equal, or close, to recent high levels."

One show of strength in the economy seen by Chase is the new high set for investments in new plants during the third quarter of 1953. Also, defense spending is scheduled to remain at the current $50 billion annual rate through mid-1954. Declining new housing starts should be shored up by easing of the mortgage market.

Seeking indicators that moved up or down, ahead of, along with, or behind general business movements, the National Bureau of Economic Research studied more than 800 economic series. Some of them were almost a century old. No single economic indicator was found reliable. The study indicated that business cycles differ. The National Bureau did discover a group of economic series that usually moves up or down in advance of business trends. The eight leading indicators settled upon have signaled past changes in business with a high degree of regularity.

The leading indicators are: dollar volume of commercial failures; industrial stock prices, new orders for durable goods, average hours worked; wholesale commodity prices; new incorporations; residential building; and nonresidential building.

By July 1948 all the leading groups were on the downgrade, but yet, business was still booming. Then, early in 1949 the roughly coincident indicators fell. The recession was on.

Leading indicators pointed downward in 1951 but a general recession was averted by a rise in military spending, according to Chase. Statistics through last September pinpoint six of the eight leading indicators on the decline. Three of the six roughly coincident indicators have also turned down. They are: industrial production; bank debits outside New York City; and freight car loadings. Experience illustrates that the roughly coincident indicators must confirm a trend.

An average of the trends of the eight leading indicators has been worked out by the National Bureau. Past performance, since 1919, shows that a trend for more than three months up or down is the critical phenomenon. When the average passed the critical point, either on the way up or down, business moved into a decided expansion or contraction. Indicators pointed down several times in the past—1947 and 1951 for example—but business only leveled out. In both cases the three-months point was not reached. Most of the leading indicators point down—but not as decisively as in 1948 and 1937. Roughly coincident indicators do not support an assumption of a downward trend. Leading indicators have not crossed the minus-three-month point supposed to be significant.

Compilation and average taking of leading indicators are not a substitute for a thorough business analysis, Chase emphasizes. Statistics are almost always behind actual developments. They also tell little about the extent of business change. Indicators can serve as an additional tool in estimating the situation. From them, it may be gathered that there will be no more than a moderate adjustment in business activity. They are one of the things to watch in the coming months.

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MINING representatives met with spokesmen for the World Trade Assn. recently in an effort to "reconcile conflicting viewpoints" on recommendations made by the San Francisco Chamber of Commerce regarding a world trade policy. Phil R. Bradley, Jr., mining committee chairman, and M. W. Melander, World Trade Assn. president, were co-chairmen of the meeting. Mining men at the meeting maintained that the tariff policy of recent years has left mining in a "bad way." World Traders pin pointed their objective to be the assurance of "an adequate and dependable flow of materials at low cost consistent with national security and the welfare of free nations."

Panel members for the Chamber's mining committee were S. H. Williston and James P. Bradley. James S. Baker and Forrest E. Brookman represented the World Trade Assn.

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IN recent years, there has been a growth of what might be termed the engineering voice. It has become important that the lay public understand the meaning of engineering and its place in civilized society. The maze of technical terms that stood between the engineer and the public has begun to diminish under a concerted attempt at better public relations. The channels that have been employed are numerous. Now, one which has only partially developed as a way to enlargement of understanding by men of the world around them offers possibly the greatest promise.

The University of Michigan, College of Engineering, has started a series of 15 half-hour programs on the adult education level called *Engineering: Building The Modern World*. The program made its debut over Station WWJ-TV, Detroit, and is carried

simultaneously over WJIM-TV, Lansing, and WKZO-TV, Kalamazoo. Six leading engineering professors carry the main load. The engineering laboratories, working well ahead of air time, have prepared demonstration material making the best use of video. The programs employ live illustrations, films, and many other visual aids.

The programs are primarily concerned with contemporary engineering accomplishments with the emphasis on graphic illustration and explanation of underlying chemical and physical principles. For those viewers who find a need for more complete knowledge, the University of Michigan's Extension Service provides supplementary material in advance of specific programs for a $2.00 fee.

Garnet R. Garrison, professor in charge of Michigan television, sums up the show's objectives this way:

"Engineering has played a dynamic part in the development of our society, but too few of us understand its fundamental principles and modern applications. Therefore, this course should be of great interest to all."

Robert R. White, professor of chemical and metallurgical engineering and coordinator of the program, believes that "the records of man's progress toward 'Life, Liberty and the Pursuit of Happiness' is written in the ledgers of engineering. . . . We are going to focus most of our attention on fundamentals, and show problems that come up when we have to use fundamentals. Engineering is always a mixture of art and science, plus intuition and guess work."

Thus, in the final analysis it is the art and science and work that go into engineering and the making of engineers that must be projected to the audience.

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THIS is democracy at work. About one year ago employees of Food Machinery & Chemical Corp. San Jose, Calif., plant decided they needed answers to questions on the American economy. A ten-week course resulted. An overwhelming majority of those taking the course were of the opinion that it was honest and had attained its objective. The course and the story behind it are told in a book written by Bertrand Klass, manager of Stanford Research Institute's social science research section.

"Democracy rests on the fundamental belief that people are better off when they think for themselves," says the author. SRI's part in the execution of the course was to test the educational effectiveness of the program as it developed and to assist in applying research results in furtherance of course aims. FMC believed that purpose of the course would be best served if information and ideas were presented first with free discussion following.

Attendance was voluntary on off-the-job-time. Production workers, office workers, and supervisors made up the participants. Husbands and wives of employees were also invited. Lecturers and discussion leaders came from Stanford University and the San Jose Education Dept. Discussion periods were the most important part of the course. "Why did we establish the Constitution of the United States? Does a social revolution always involve bloodshed and war? How much net profit does industry make? Are political parties pressure groups?" were some of the questions which were talked out.

An economist, a union official, and a congressional representative each spoke at pertinent sessions. Reaction to the program was so encouraging that a third in the series has been undertaken for FMC employees under the leadership of Graham Stuart, Professor Emeritus of political science at Stanford University.

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PENNSYLVANIA Coal & Coke Co., and the Eagle-Picher Co. have turned pessimistic in their attitude toward extraction of germanium from coal. Both companies have been following extensive research programs. They have analyzed hundreds of samples of coal from widely separated deposits—finding almost nothing. Their conclusions have been reached reluctantly, but Eric Mitchel, vice president for operations of Pennsylvania sums up his firm's efforts this way: "Actual analysis of germanium in coal showed no justification for going after it. But this does not mean we will stop hunting. Meanwhile recovery is best from fly ash. We must change our optimism so far as coal deposits are concerned." Undismayed, the Pittsburgh office of the Bureau of Mines continues to experiment with germanium from coal in an assist play to the Signal Corps.

A. P. Thompson, Eagle-Picher director of research, whose firm combined research forces with Pennsylvania Coal in the hunt for germanium-bearing coal, said: "There is no question but what too bright a picture has been painted with respect to the profitable recovery of germanium from coal. Frankly, under present economic conditions and taking into consideration the many factors involved, even under the best conditions, coal does not appear a likely source of germanium."

Mr. Thompson based the attitude of his firm on certain factors: Not all coals contain germanium, and research has disclosed that content at best is low, and distribution erratic through the vertical and lateral extent of the seam; germanium tends to be concentrated in the top or bottom two or three in. of the seam, but concentrations are too low and spotty to warrant selective mining; the best coals rarely show more than 0.002 or 0.003 pct germanium, so little that direct recovery would not be practical; the extremely small quantities of germanium in coal makes it almost absolutely necessary that germanium be recovered as a byproduct after utilization of the caloric content of the coal; germanium extraction from coal combustion is expensive and difficult, and involves high losses at every step; and the germanium market is unstable, seeming to decline at present.

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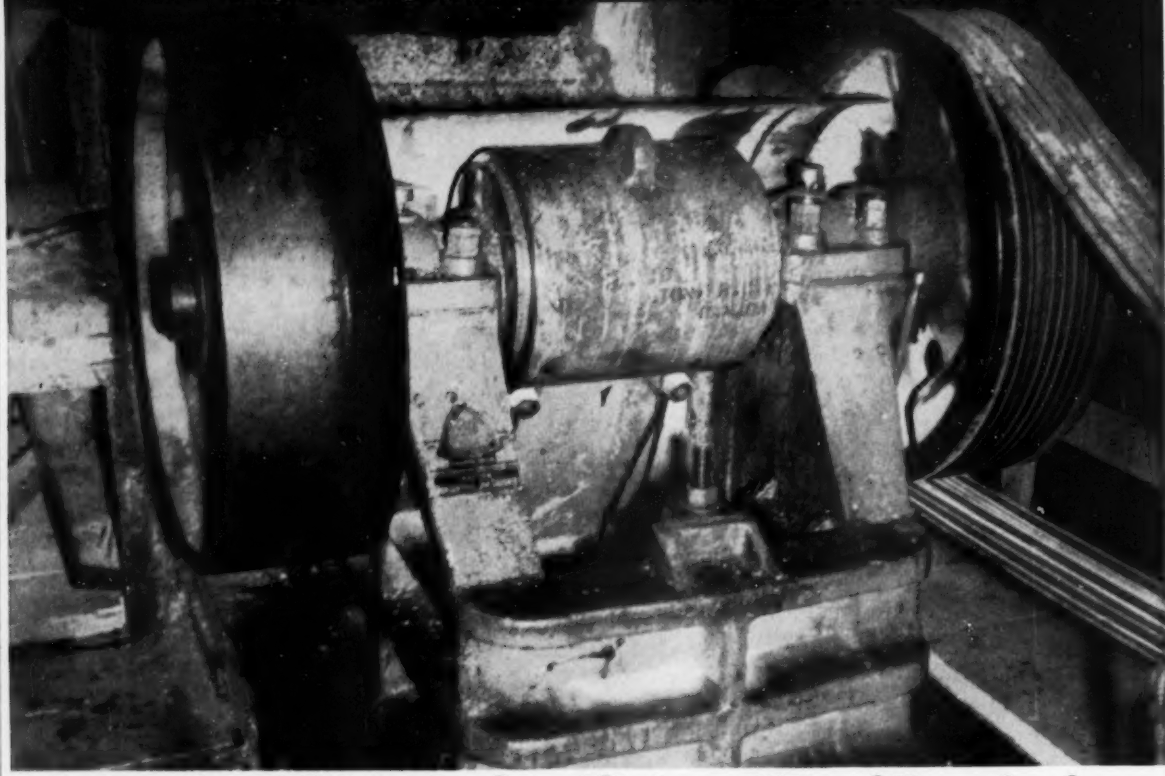

Denver Type 'H' Jaw Crushers Eliminate 95% of Your Crusher Bearing Troubles. The Reason: Anti-Friction Bumper Bearings

Bronze bumper bearings in low-cost crushers have always been a source of trouble. Deco has eliminated these difficulties and still remained in the moderate price field with the Denver Type "H" Forced Feed Jaw Crusher.

ANTI-FRICTION BUMPER BEARING

A heavy-duty roller bearing has been designed into the bumper, the most serious zone of bearing trouble. (Deco research engineers found 95% of all crusher break-downs were caused by failure of old-fashioned bumper bearings.) Also, a large diameter alloy steel shaft reduces shaft deflection on the bearings, this gives longer bearing life.

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Frames on the 8″ x 10″ and larger sizes of the Denver Type "H" Crusher are electric cast steel. The frame is also heavily reinforced to withstand severe service.

OTHER CONSTRUCTION FEATURES

Jaw plates are reversible 13%-14% manganese steel. The bumper is heavy, electric cast steel. Grease fittings are conveniently located, and bearings are sealed against dirt.

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Denver Type "H" Forced Feed Jaw Crushers are available in sizes 2¼″ x 3½″, 3¼″ x 4½″, 5″ x 6″, 8″ x 10″, 10″ x 16″, 10″ x 20″, and 11″ x 30″. Shipment of most sizes is normally made direct from stock, so you can get immediate delivery!

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Denver Type "J" Jaw Crushers—with both anti-friction bumper and side bearings, and one-piece steel frame are available from 9″ x 12″ through 32″ x 40″.

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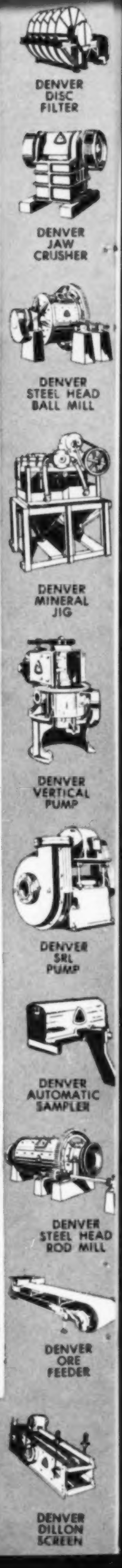

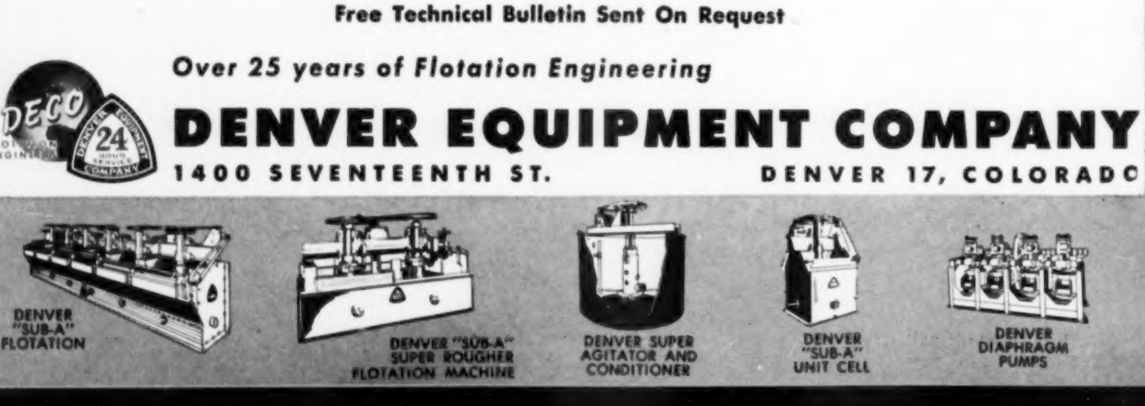

Drift of Things

AS a Christmas present to the Editors we are contributing a few paragraphs this month to our old love, "The Drift of Things," knowing by experience how welcome some copy to fill a yawning hole in the makeup can be. We think that the ideas we are about to put down on paper should be a valuable gift to the officials of mining and metallurgical companies as well. Not an outright gift, because it will cost the companies something to carry out our proposal, but if they make the investment we think it will pay big dividends.

At the Dallas meeting of the Petroleum Branch, in October, a record attendance was registered—some 1760 men, and an estimated 600 to 700 ladies. We were struck by the fact that such a large ratio of ladies was present and also by the fact it was a youthful crowd, a large proportion plainly being in their twenties and thirties. Remarking on these observations we were told that a great many of the companies had been exceedingly liberal in allowing their younger operating men to attend the meeting—not just allowing them to go, either, but sending them, paying their expenses, *including their wives*.

Now the business acumen of the oil companies' management is well known. They have plenty of ideas and in general they pay off. Money is freely spent, but only when there is a good chance that such spending will ultimately mean higher earnings for the company. Every investor in oil stocks in the last decade or two knows how successful they have been.

Investment of a few hundred dollars a year in increasing the technical competence and the professional stature of a young employe, to say nothing of building up his morale and his loyalty to the company, will pay high dividends. A raise in salary is considered more or less routine, but a trip to an important meeting of his professional society, with all expenses paid, is a gift of the gods, an unexpected reward that makes possible fulfillment of an ardent wish. The young man is getting the same privilege as the top brass.

In about two months, the Annual Meeting of the AIME will be held in New York. There will be four full days of opportunity to attend technical sessions and to rub shoulders with those who are engaged in a common professional field. Among the 300-odd papers are some that come close to home to practically every AIME member. Much of the discussion will never be printed. The most valuable discussion is often never even heard in public. What pays off best is what is learned in the corridors and the private rooms. You tell somebody what you are trying to do. He tells you he has tried that and it won't work. He tells you a better way, and makes you a sketch. When you later find that his way won't work either you write him a letter, or call him on the phone, or visit his plant. Between you the problem is solved. By going to the meeting, *you know whom to approach*.

A young man can in many respects get more out of a meeting than an older man. His mind is open and fresh. He needs to know more people, and if he is well coached he will meet them. He will come back with many new ideas, any one of which may well turn out to be worth many times the cost of sending him to the convention. Some excellent advice on how to make the most out of attendance at a professional gathering was published on these pages in January 1949 in an article by Herb Rose entitled "Getting Your Money's Worth." Reprints are available on request.

Time was when a trip to and from New York from a Western mining district took more time than did the actual meeting itself. Now, one can travel from Los Angeles to New York in 7¼ hr. A week, at most, is all that is required to go from almost any place in North America and take in the entire AIME Annual Meeting. Few men are so necessary to a company's operation that they cannot be spared for that length of time. Suppose they had the flu or something.

Once we heard an executive say that if he sent his younger men to meetings he would lose them—they would get better jobs. If a man seeks another job it is usually because he is dissatisfied where he is, and if that is the case he will leave sooner or later anyway unless the company removes the causes of his dissatisfaction. If a man is loyal to his employer, happy in his work, and merely succumbs to a better offer from someone else, no self-respecting employer should stand in the way of his advancement. He might ask himself if that is not the way he, too, got ahead in the profession.

Some young men have complained to us that they were not permitted to attend an AIME meeting even if they paid their own expenses. Certainly it is hard to see how a man could accomplish less in four days at a meeting than in continuing routine work. Some employers permit a man to attend but at his own expense. This bars most young men with families from coming to New York, so if he is to profit from the opportunity the young man must have some pocket money. The really far-sighted employer will not pinch present pennies and sacrifice later dollars. On the week end of December 20 he will review which members of his staff deserve and are likely to get the most out of coming to the Annual Meeting. On Christmas morning he will call them up. "Merry Christmas, Bill," he will say; "I have decided that you and Mary should represent us in New York for the AIME February meeting. I believe the ideas you will get and the contacts you will make will prove that your trip is a good investment for us. I will send you a paper on how to get the most out of the meeting. When you get back you can give us a little report."

Bill will think that's the finest Christmas present he ever got. He will do his utmost to see that the company's confidence in him has not been misplaced. He will be convinced that he works for a fine company and that his boss has his eye on him. Don't tell us that those few hundred dollars will have been unwisely spent!

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SPECIFICATIONS

Headroom	12'0" to 16'6"
Discharge Height	7'3" to 11'4"
Overall Length	15'1¾" to 17'6"
Digging Below Grade	17"
Track Gauge (Standard)	74"
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Mining Engineering

The New Jersey Zinc Story

FOR this Famous Mining Enterprise issue MINING ENGINEERING selected the company that started the zinc industry in the United States.

The New Jersey Zinc Co. has been a supplier of zinc products to the nation's industries for more than 104 years. Its Horse Head trade mark is famous throughout the world.

The excellent reputation of its products for high quality and uniformity is the result of an extensive control, sampling, testing, and inspection system established many years ago by a far-sighted management. Holding its Horse Head Special 99.99+ pct zinc to less than 0.009 pct total impurities is a routine day-to-day procedure. In the production of its many types and grades of zinc oxide it follows over 100 specifications and requirements for color, brightness, smoothness, oil absorption, and other characteristics demanded by customers. All of its other products must run a similar gamut of inspection, testing, and checking before a shipment leaves the plants. It exercises the same care in testing and grading all raw materials delivered to its smelters.

Everyone in the organization is constantly reminded of the importance of the product quality and uniformity, and the company is quick to point out that its ability to consistently meet customer requirements is the largest contributing factor in its successful operation over the past century.

Its management, its engineering staff, and its large group of mining and smelting experts are ever on the alert for new and improved methods and processes. A continuing program of modernization at its mines and plants has resulted in constant increases in efficiency of its operations. Due to recent fluctuations in the price of zinc, the company has become even more cost conscious, and its current program places greater emphasis on production efficiency all along the line.

Members of the mining and smelting professions, both new and old, the great variety of industries served by New Jersey Zinc over the years, the financial world, and the public-at-large know the company as a conservative, well-managed organization with an outstanding record of earnings over an extended period of years.

There can be no doubt that the organization has maintained leadership in its field. Attribute it to the ability to produce the quality product—consistently. Call it good management, or engineering know-how, or something else. But repeated interviews with officials reveal no magic formula for the company's outstanding record of achievement.

Perhaps the best answer can be found in the fact that New Jersey Zinc has operated successfully for over a century in the true American tradition. It is a typical example of the competitive free enterprise system of our nation. With strict adherence to the basic tenets of this system, it has consistently made improvements in its products and processes, constantly striven to reduce its cost of operation in order to improve its competitive position, provided steady employment for thousands of people, and year after year paid stockholders a reasonable return on their investments. It's as simple as that.

In the pages that follow, MINING ENGINEERING is privileged to publish for the first time a complete and authoritative account of the operations of America's oldest producer of zinc.

The New Jersey Zinc Co.

. . . in its 105th year . . .

An introduction to the company and its products

EARLIEST records of the Franklin-Sterling orebodies show that the outcrops were explored in 1640, shortly after the establishment of the Nieuw Amsterdam settlement. In 1760, the name of William Alexander, the Earl of Stirling, became associated with the property. Although the Earl was unsuccessful in his attempts to work the zinc deposits, he did produce some much needed iron for the growing Colonies. Other operations became active from 1765 until 1848 when a group of venturesome men formed the Sussex Zinc & Copper Mining & Mfg. Co. (it became New Jersey Zinc Co. in 1852), to work the orebodies of the now world famous zinc mines of the Franklin-Sterling area in Sussex County, N. J. One of the properties, Sterling mine, is still a principal source of zinc ore for New Jersey Zinc.

But all these previous attempts to get the Franklin-Sterling orebody to yield its zinc were unsuccessful, and it was not until 1852, four years after the new company took over, that the first satisfactory method of smelting the ores was developed. Zinc oxide was the first product of this process, forerunner of the well-known American Process, by which most of today's zinc oxide is produced.

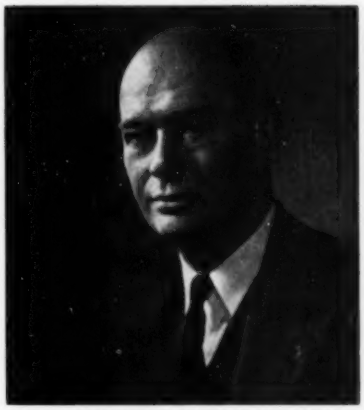
From the beginning, the company worked on the recovery of metallic zinc from the Franklin-Sterling ores, but one method after another proved unsatisfactory. Finally in 1865 it brought forth a successful method, and slab zinc became a commercial product. Before this, however, in 1855, through experiments with a modified pig iron furnace it was able to produce an alloy of iron and manganese called spiegeleisen for use by the steel industry.

The company, producing these three products at an increasing rate, was a growing enterprise. But other companies had come into the area and had obtained rights to certain sections of the orebody. A question of wording of certain deeds from one of the previous owners started a series of legal actions which was to last until 1897 when the companies consolidated, and the new organization took the name of The New Jersey Zinc Co.

Shortly thereafter, an active program of expansion got underway. Plans were drawn for the construction of the large smelting plant at Palmerton, Pa. Production was started there in 1899, and its first products were slab zinc, zinc oxide, and spiegeleisen.

In 1905, additional smelting capacity was needed to take care of demand for slab zinc in the Middle West, and a new plant was built in Depue, Ill. About the same time, the mine at Austinville, Va., acquired in 1901, began to develop into a large producer of high grade zinc and lead concentrates. Another mine at Hanover, N. Mex., came into the family in 1903 and has operated intermittently ever since. The famous Eagle mine in Gilman, Colo., was purchased in 1915. Not far from this mine, in Canon City, is a plant where Eagle's concentrates are roasted and shipped on to the Palmerton and Depue smelters.

P. M. GINDER, Vice President in charge of manufacturing. Description of the plants starts on page 1233.



R. L. McCANN, President of New Jersey Zinc, appears here with the heads of the operations covered in this issue.

S. S. GOODWIN, Vice President in charge of mining and exploration. Articles on this phase of operations begin on page 1206.

At the present time The New Jersey Zinc Co. has new mines in the process of development at Friedensville, Pa., Ivanhoe and Mineral, Va., and Jefferson City, Tenn., which are expected to be in production in the not too far distant future.

New Jersey Zinc's service to the large industries of our country extends over a long period, in some cases a century. The paint industry, for instance, has been using its zinc oxides since 1852, when for the first time it was able to buy domestic zinc oxide, made direct from zinc ore. This 101-year old invention set the stage for the development of the ready-mixed paint industry which today is one of the nation's billion dollar businesses.

The rubber industry, largest consumer of New Jersey Zinc oxides, has been a steady customer since before the advent of the automobile. Zinc oxide's dual role in rubber compounding — its ability to shorten the curing time in processing, and its function as a reinforcing agent, has made it an essential ingredient in the manufacture of tires, tubes, and other rubber goods.

New Jersey Zinc's pigments have served the ceramic industry since Civil War days, and the cosmetic industry since 1870.

Its development of luminescent pigments based on zinc sulphide pigments served many important World War II purposes, and today these pigments are used in a variety of commercial applications.

New Jersey Zinc played a major role in the development of an industry which today constitutes the largest consuming outlet for its well-known Horse Head Special 99.99+ pct zinc — the die casting industry.

Some 25 years ago New Jersey Zinc engineers perfected new and improved die casting alloys, called Zamak, based on high purity zinc. At the time, the die casting industry was consuming about 12,000 or 13,000 tons of zinc annually in alloys of inferior strength and stability. The adoption of the new alloys started the industry on its way to becoming one of the major high speed producers of metal parts of the country. Today the die casting industry uses high purity zinc at the rate of nearly 300,000 tons annually.

Substantial amounts of the company's metal are consumed by the brass industry for the production of strip brass, chiefly, and by the steel industry in the electrogalvanizing process and for special types of hot dip galvanized wire.

New Jersey Zinc has been in the rolled zinc and rolled zinc alloy business for many years and its specially rolled products enjoy widespread acceptance in the dry cell battery can and weatherstripping fields. It is also a large producer of spiegeleisen and sulphuric acid.

It has recently entered the field of powder metallurgy and its present line includes brass, bronze, copper, and nickel silver. Such products are finding increasing use in the fabrication, by compacting, of small metal parts.

The Horse Head

New Jersey Zinc's familiar Horse Head trade mark, which appears on all of its products, was adopted in 1855. Its origin goes back to the year 1786, when the one cent piece of the Colony of New Jersey was first minted. On this coin appeared the horse head and plow which now form the Great Seal of the State of New Jersey. It was from this seal that New Jersey Zinc's trade mark was taken.

In the spring of 1848, on a site near the present Pennsylvania Railroad Station in Newark, N. J., experimental furnaces were erected by The New Jersey Zinc Co. for the first commercial attempt to distill slab zinc in this country. The operation actually was used for the manufacture of zinc oxide, and it was here at Newark that the Horse Head crest first put in its appearance. Interestingly enough this device was cast in the furnace doors, above the company name.

Earliest recorded use of the Horse Head crest on a product is on a label used in connection with "Number 1 White Zinc, Ground in Oil"; the date about 1855. Today Horse Head products include a complete line of zinc pigments, namely: zinc oxide, zinc sulphide, lithopone, zinc dust, and luminescent pigments. Zinc metals carrying this mark include slab zinc, special high purity zinc for the die casting industry, rolled zinc, rolled zinc alloys, also metal powders, spiegeleisen, cadmium, and sulphuric acid.

New Jersey Zinc

Exploration

"...only a small fraction of the orebodies available for discovery in the U. S. have been found...current exploration methods make available an enormous volume of ground for exploration."

by William H. Callahan

THE life span of a mining company operating solely in the U. S. today is in direct proportion to the success of its exploration effort. This is in contrast to the situation some years ago when companies could rely on appreciable opportunity to purchase interests in discoveries made by prospectors.

The reduction in activity of prospectors has come about because of the lack of opportunity to find orebodies in outcrop, the high cost of finding buried or blind orebodies, and the difficulty of financing such speculative ventures by public subscription. Accordingly there has been a marked increase in exploration effort by industry and by government. Someone must continue the work of the prospector if the U. S. is to maintain its own supply of raw materials.

It is appropriate that mining companies take the initiative in mineral exploration if they wish to survive in a free enterprise system. To do so, thinking must be in regional terms, but not only with respect to the potential of known mineralized areas. Thinking must also be focused on those large areas in which a mineral potential cannot be denied, but likewise cannot easily be confirmed, because of few outcrops, or outcrops which are not amenable to examination by conventional geologic procedures. Examples of this kind are the gravel-filled valleys and lava-capped areas in the west, the mid-continent area from Arkansas and Oklahoma to Great Slave Lake where there are scattered outcrops of lead-zinc ore and where zinc has been found at substantial depth in oil tests, and soil-covered areas of the eastern states.

Justification of exploration of this kind must rest on the conviction that orebodies remain to be found and that available procedures can find them. The effort has required an increase in staff and the dedication of substantial funds. In the opinion of The New Jersey Zinc Co., the probability of success varies not only with the validity of the concepts involved but also with the continuity of the effort. As in any research, a soundly conceived program persistently applied is more apt to be fruitful than an intermittent one however brilliantly conceived. To provide continuity we distinguish two phases of exploration — *looking* and *digging*. The looking is continuous without excessive cost and involves the use of conventional geologic procedures and the application of geophysical and geochemical methods under geological control. The digging can be tailored to fit economic conditions. By adjustment of the two phases, staff can be maintained at a fairly constant level.

In such an exploration program we accept the following basic concepts: (1) Mineral deposits were formed during several periods of earth history. They formed in rocks of diverse age, type, and geologic setting at various depth intervals within a great range in the crust of the earth and by a diversity of natural processes. (2) Some of the deposits have been completely removed by erosion. Others, having survived one or more periods of erosion and burial, outcrop today. Still others, after partial erosion, are buried under younger sediments, volcanics, water or ice. Still others are blind, never having been exposed to the light of day. It is mere chance which one of these situations exists with respect to any orebody. (3) In the U. S. today there is small chance of discovering a base metal orebody in outcrop. (4) Future discoveries will be made by exploration of geologic, geochemical or geophysical anomalies alone or in combination.

Our direct observations and measurements are restricted to a small vertical range — the earth's surface, the modest depth reached by mines and drill holes, and the lower levels of the atmosphere suitable for airborne exploration. Consequently we must strive for thorough knowledge of the materials of the earth's surface and be concerned with the distance between our points of observation or measurement and the possible location of blind or buried orebodies since these factors control our ability to find ore. The nature of the surface materials limits our ability to discover significant anomalies. The distance factor along with the size, shape, attitude, and composition of the orebody and the nature and structure of the enclosing and covering rock determine the effectiveness of geochemical or geophysical procedures.

Because of the direct control on the range of de-

W. H. Callahan, Manager of exploration.

tectability of ore deposits exerted by the processes of erosion, one is reminded of Robert Frost's poem,

'Tis the world-old way of the rain
When it comes to mountain farm
To exact for a present gain
*A little of future harm.**

As with farms so it is with orebodies. We have gained from the rains an opportunity to discover orebodies in outcrop or exploration guides in the form of alteration and weak mineralization. Also in some cases the rain has enriched the ore remaining or converted waste to ore. The harm suffered is the removal of valuable ore and its dispersal beyond recovery or the burial of ore outcrops under worthless debris.

The orebody at Franklin, N. J., is an example of the gain and the harm involved in erosion. Three accidents of erosion exposed it and yet did not remove all the ore. It was exposed by erosion in pre-Cambrian time and was later buried by Paleozoic sediment. Subsequently the sedimentary cover was removed but the ore was again buried, this time by glacial material which in turn was eroded to permit discovery of the ore. This case, not uncommon, is a striking example of the fact that the industrial might of the U.S., which has developed almost entirely within the life of this great mine, stems from the remnants of orebodies which by accident were exposed by, but in part, survived erosion.

And yet in our government circles today it is the fashion to use the remnants of these accidents of erosion and survival as a measure of our total mineral resources, and to conclude therefrom that this is a Have Not nation. What we *have not*, other than mining and tax laws properly designed to encourage exploration, is adequate information on which to forecast the occurrence of blind or buried orebodies, of which there are undoubtedly many. And while admittedly there is small chance for finding a base metal orebody in outcrop in the U. S., it is the writer's belief, and that of many other mining geologists, that the U. S. is as yet largely unexplored and that only a small fraction of the orebodies available for discovery have been found, i.e., within the range of detectability of currently available exploration methods. Even though such methods may have a range of only a few hundred feet, they make available an enormous volume of ground for exploration. On this basis we are prepared to engage in exploration.

The mineral industry today is somewhat in the position of the oil industry when it had to find some basis other than seepages to guide its exploration. The oil industry solved its problem by regional geologic studies and by developing, along with independent geophysicists, instruments capable of measuring geologic factors not determinable by conventional geologic techniques. Some of these instruments are being used by the mining industry and by Government and have been responsible for ore discoveries. The iron deposits at Morgantown, Pa., and Marmora, Ont., some of the base metal sulphide discoveries in New Brunswick and many uranium deposits are recent examples that come to mind.

To aid in the application of physical and chemical methods to exploration problems, the research dept. of New Jersey Zinc has supplied the services of its scientific staff. It has established a section entirely devoted to geophysical research, and to the study and improvement of existing methods and instruments. The scientific personnel employed in this section go into the field and aid in the geophysical work necessary for our exploration procedures. They take back field problems to the laboratory and conduct research to solve them. They supply interpretations of field data to geologists in the field. Their facilities for making thin and polished sections, X-ray and spectrographic determinations, and electron micrographs and their reports thereon are of real assistance in geologic investigations. Personnel in the chemical section have cooperated in the development and standardization of analytical procedures in geochemistry and in the interpretation of results.

Close liaison is maintained with the mining dept. in the conduct of exploration projects and the evaluation of results. Many of our exploration units are based at mining properties and are an integral part of that mine property organization. They act as the geologic staff at the mine and investigate the region nearby, or operate from subsidiary bases where convenient to do so. In this way the facilities of the mining operations and the experience of the mining staffs are made available for exploration work. In areas remote from our mining operations, exploration units operate on their own and report directly to the main office. Property matters are handled by the exploration staff with the aid of our legal dept. and attorneys retained in areas of interest.

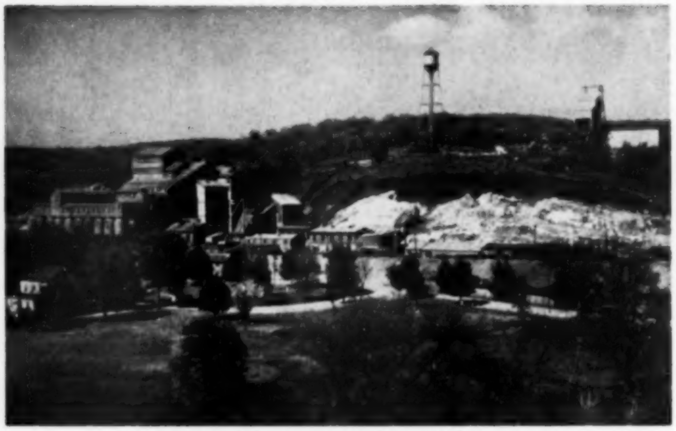
Exploration is being conducted in the eastern states, in the mid-continent area, and in several of the western states, and in British Columbia, Quebec, New Brunswick, and Newfoundland.

In current exploration efforts 70 geologists and a total of 100 people are employed, exclusive of research dept. personnel. Twenty-five drill rigs are operating under contract, and about $1.5 million is being expended annually. As a result of these efforts the life of the Austinville, Va., mine was substantially lengthened, new mines are being opened at Ivanhoe, Va., and Jefferson City, Tenn., and rehabilitation of underground workings is in progress at Mineral, Va.

* "In Time of Cloudburst" from *Complete Poems* of Robert Frost used with permission of Henry Holt & Co. Inc.

New Jersey Zinc

Franklin-Sterling Operations



The Sterling mine, Ogdensburg, N. J.

Operations at the world-famous and mineralogically unique Franklin and Sterling mines date back more than a century— It was here that solution of a metallurgical mystery laid the cornerstone for the 105 years of New Jersey Zinc history.

THE New Jersey Zinc Co. operates two mines in northwestern New Jersey about 45 miles from New York. The Franklin mine is at Franklin and the Sterling mine at Ogdensburg, N. J.

Ore deposits are unique in that approximately 160 minerals have been identified. Of this large number of minerals, only three, zincite, willemite, and franklinite are of economic importance. Franklinite has never been found in any other locality.

Existence of the Sterling ore deposit was known about 1640 and records indicate knowledge of the Franklin ore deposit prior to 1750. Ore was first mined from the Franklin deposit about 1848 and from the Sterling deposit shortly before 1852.

Geology of the Ore Deposits

by John L. Baum

GEOLOGICALLY the Franklin and Sterling ore deposits are rather similar. Each appears to represent the replacement of a large north-eastward plunging dragfold in pre-Cambrian metamorphosed limestone. In each, the ore consists of 40 pct franklinite, the oxide of iron, zinc, and manganese; 23 pct willemite, the silicate of zinc; less that 1 pct zincite, the oxide of zinc; and 36 pct combined gangue silicates and carbonates. In general, the ore is well banded on too fine a scale to permit selective mining of individual bands, but at the Sterling mine a unique occurrence of black willemite is of sufficient size to be removed separately. In both plan and section the orebodies have a pronounced hook shape, with the added complication at Sterling of a cross vein between the two portions of the hook. It is this cross vein which is in part composed of black willemite, a microscopic mixture of willemite peppered through with franklinite.

The longer limbs of the Franklin and Sterling orebodies dip about 55° southeast. At Franklin the east limb is the shorter, and it is essentially vertical. At Sterling, the west limb is the shorter, and it is parallel to the east limb, the latter being overturned. The plunge of the fold at Franklin is 25°, while that at Sterling is 45°. The Franklin orebody lies within a few feet of the eastward dipping contact between the enclosing Franklin limestone and

John L. Baum is Chief Geologist at Franklin-Sterling.

adjacent metasedimentary gneisses on the west, while the Sterling orebody is 400 to 800 ft from the same contact. The two mines are separated along strike by 3 miles of unmineralized limestone. In general the mineable limits of the ore are well defined, but locally at Franklin the presence of lean ore along the hanging wall contact produces assay limits which must be carefully controlled to avoid undue dilution.

The Franklin orebody is 1150 ft deep vertically, whereas, the Sterling orebody has a vertical depth of 2500 ft.

Left to right: Warren Hastings, Sterling Mine Superintendent; C. M. Haight, Franklin Mine Superintendent; W. F. Evans, General Superintendent; J. S. Pellet, Superintendent, Franklin-Sterling Plant Dept.

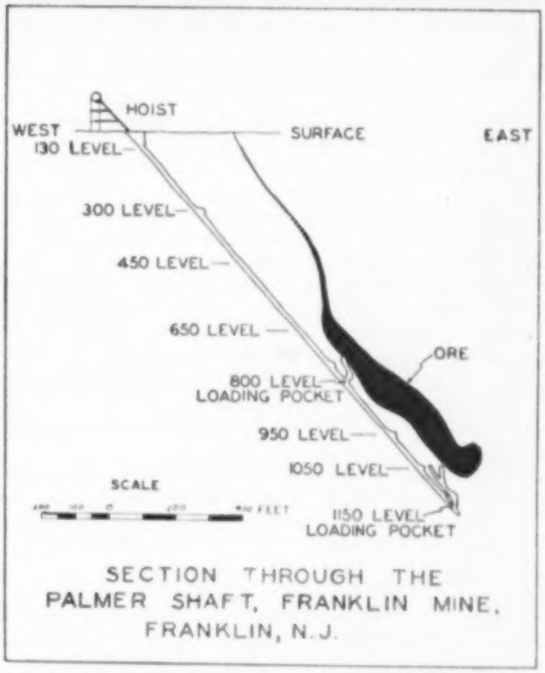
The Franklin Mine

by C. M. Haight

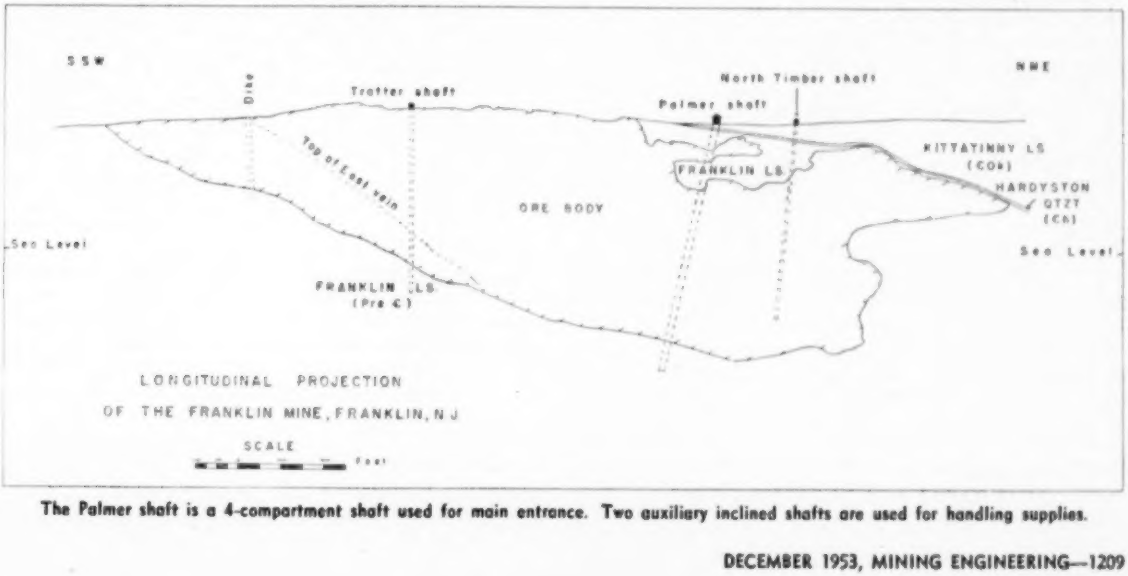
THE orebody at the Franklin mine is an inclined trough dipping about 25° to the north; the west side outcrops for most of its length; the top of the east side, after outcropping for several hundred feet from the south end, dips beneath the surface at about 35°. The ore-bearing minerals are franklinite, willemite, and zincite.

First mining was by shrinkage stopes; where the width of the ore was narrow the stopes were carried along the strike, where too wide for this they were carried at right angles to the strike. Both types were started from a level and carried to the one next above, then emptied of the broken ore, and the space was filled with waste rock quarried at the surface, and mill tailings.

Pillars between the stopes, 30 to 45 ft wide, are mined by top slice methods, with entrances from main level drifts in the footwall rock. The hardness of the ore necessitates much heavier blasting than the usual type of ore mined by this method, and the fill in the old stopes must be held back until the



This section shows the orebody at the main operating shaft.



The Palmer shaft is a 4-compartment shaft used for main entrance. Two auxiliary inclined shafts are used for handling supplies.

working place is blasted down. The broken ore is moved by slushing to raises which lead to the haulage system. Haulage is by trolley and storage battery locomotives; gable bottom cars of 2½ and 4-ton capacity are used.

Entrance to the mine is by a 4-compartment shaft, inclined at 47½° in which hoisting can be done in all compartments. Skips of 6-ton capacity are hoisted by direct connected steam hoists after being loaded from shaft pockets operated by hydraulic rams powered from the pump column. There are two auxiliary inclined shafts handling supplies.

Water from the lowest sump is pumped against a head of 130 ft to the main pumping station where electrically driven centrifugal pumps with a total capacity of 1400 gpm raise all mine water to the surface against a head of 1000 ft. All pumps are automatically controlled. Most of the water flows through a flood control system which automatically holds back excess water when the flow is heavy.

The Sterling Mine

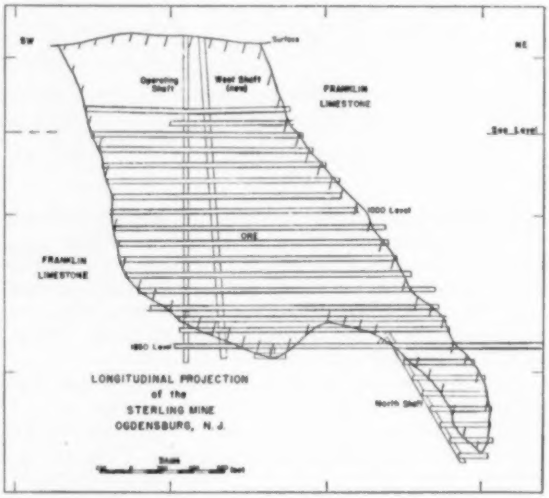
by Warren Hastings

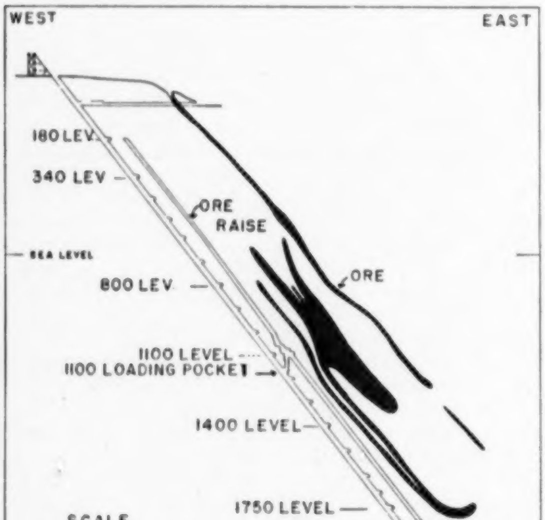
THIS orebody, 3 miles south of the Franklin operation, consists of a northward pitching trough with outcrop at the south. Local splitting of the northward extension of the east leg is of common occurrence and several well-defined faults are instrumental in adding to the complications of an extremely irregular ore occurrence.

Early mining activities were limited to quarrying of the outcrop and minor stoping of upper portions of the east leg. Current operations were initiated in 1912 and sinking of the present 57° operating shaft was commenced the following year.

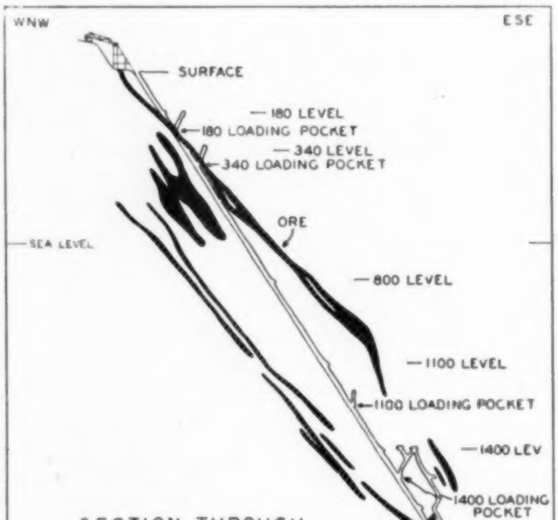
Ore removal is by transverse and longitudinal shrinkage stoping, the former being laid out on 40-ft centers, with stope widths of 19 ft separated by temporary line pillars 21 ft in thickness. Following removal of broken ore and tight filling of the stopes, pillars are recovered by undercut inclined slicing, accompanied by breasting back of the adjacent stope fill.

Crown pillars are recovered by square setting, and horizontal cut and fill mining of sections, where the

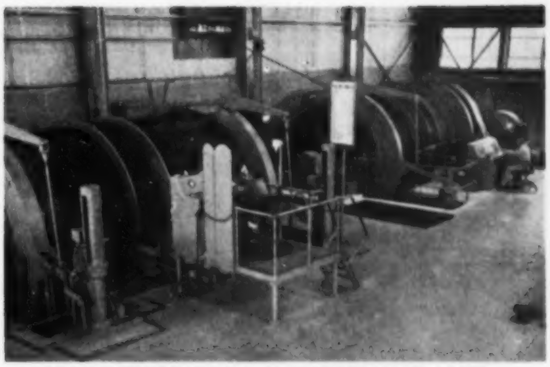




SECTION THROUGH WEST SHAFT
STERLING MINE, OGDENSBURG, N.J.



SECTION THROUGH
OPERATING SHAFT, STERLING MINE,
OGDENSBURG, N.J.



Left: Recently completed station in the Sterling mine. Right: The ore hoist at the left, and the man hoist at the right serve the new main shaft at Sterling.

hanging wall is extremely weak, is in contemplation.

Ore is drawn directly or slushed to loading chutes from which it is transported by means of storage battery locomotives. All openings resulting from ore removal are tightly filled with quarry and development rock, gravel and tailing to prevent caving of walls and surface subsidence.

Rock bolting is practiced, while jackleg drilling with insert bits is employed in pillar mining, miscellaneous strip work, and hitch cutting.

An extensive development program, now approaching completion, includes a five compartment 30x8-ft, 52° slope shaft to be equipped with balanced 6½-ton ore skips and 40-man capacity service cages. This shaft will service all operations to and including the 1850-ft level, and primary crushing to 4-in. size will be performed ahead of the two shaft loading pockets.

All shaft construction is of steel and concrete, with the exception of 2-in. cushion planks between the rail and supporting wide flange beams laid parallel to the track.

A second shaft, of similar construction but of 18x8-ft cross section, is completed to service a downward extension of ore toward the north, production from it being transferred to the main shaft for delivery to the surface.

Milling at Franklin and Sterling

by J. S. Pellett

EARLIER smelting of Franklin and Sterling ores for zinc metal was limited to a relatively small production of hand-sorted zincite and sorted and washed calamine ore from Sterling. Inability to separate the iron bearing franklinite from the almost equally heavy willemite and zincite restricted use of the characteristic complex ores to burning for zinc oxide.

Necessity for removal of the franklinite and various still less magnetic silicate minerals led to invention and development of the Wetherill high intensity magnetic separators, and in 1896 to construction of a 150-ton mill at Franklin. Shortly thereafter, jigging and tabling equipment was installed for discarding the calcite gangue. This was followed by the production of willemite-zincite concentrate suitable for metal production. With many improvements, the same separating principles have been employed on the present mill site at Franklin since 1901, and at Ogdensburg for Sterling ore since 1915.

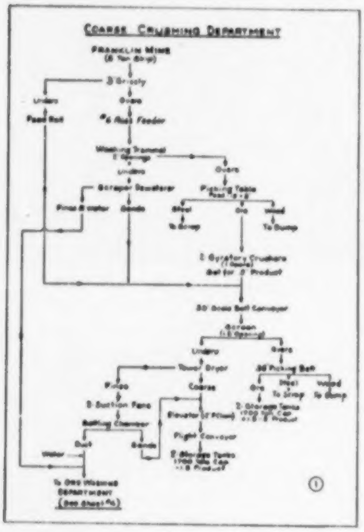
With the exception of part of the Sterling ore which is separately hoisted and processed, the component minerals can be sufficiently liberated to start separation at approximately 8 mesh size, but with production of approximately 10 pct weight of sizes too fine for the separating processes. Such fines are advantageously shipped to Palmerton, Pa., for Waelz kiln processing to crude zinc oxide.

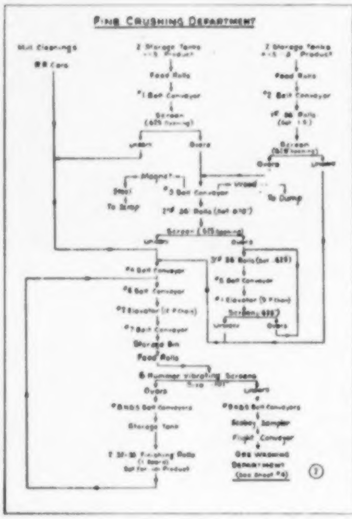
At Franklin, run-of-mine ore up Palmer Shaft is crushed to −3 in. size in two gyratory crushers and then screened at 1⅛-in. size. Undersize falls through a tower dryer to reduce the moisture to about 1 pct as necessary for subsequent handling. The resulting fine and coarse sizes go to separate storage bins as feed to the fine crushing department.

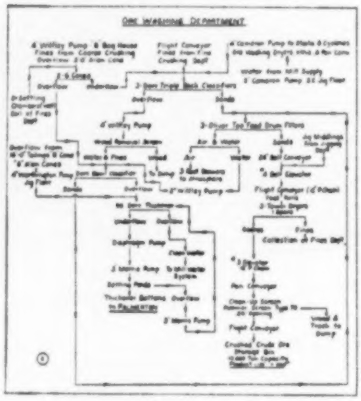
Fine crushing to −0.1 in. is accomplished through a train of four sets of rolls, the last in closed circuit with six 4x5-ft Hummer screens. The screen undersize is distributed to three triple-deck rake classifiers, which overflow −100 mesh sizes to a thickener and then to storage ponds for draining and shipment. The classifiers produce sands which pass to three rotary hopper dewaterers which reduce the moisture to 6 pct and deliver them by conveyor to two of three tower dryers. The dry and deslimed ore then goes to a 9000-ton storage bin for feeding the separating departments.

Resulting from plant enlargements, the separating operations are divided between two buildings, Separator Houses A and B, on opposite sides of the large storage bin. The feed originally goes to screens in the upper part of House B from which −28 mesh undersize goes to 12 two-pole preliminary followed by 24 four-pole final Wetherill separators, all of which produce franklinite for shipment. The final separators also produce *half and half* for shipment and Waelz kiln processing. This is a middling product composed of fine attachments and various feebly magnetic silicate minerals which are undesirable in both the franklinite and willemite products. The nonmagnetic product from the final Wetherill machines goes to two surge bins for feeding two groups of 24 Wilfley tables, preceded by desliming cones and multiple pocket hindered settling classifiers. These tables produce calcite tailing sent to the

Unique ore calls for unique treatment—Wetherill high intensity separators were evolved here.

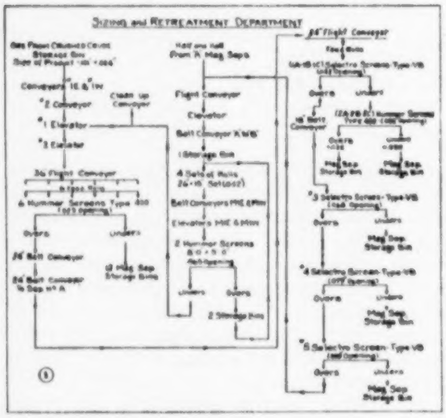


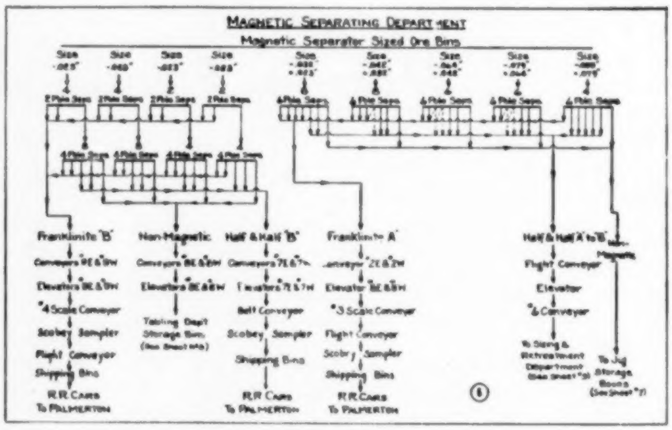


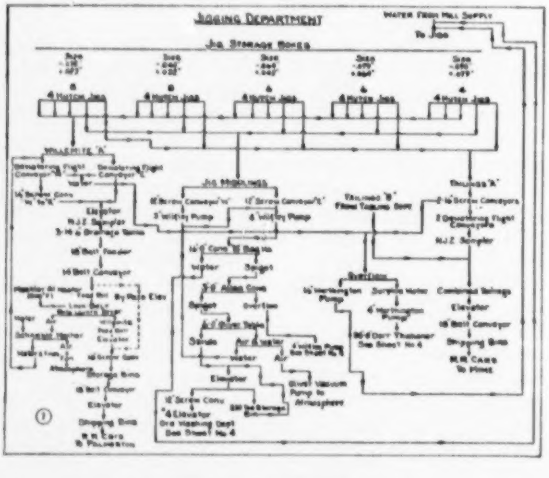


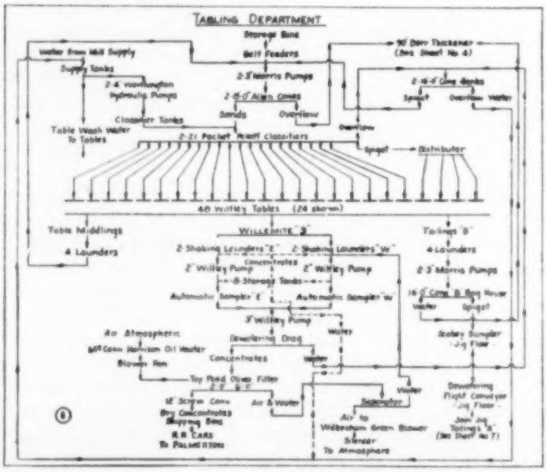
COLLECTION OF FINES: Air from ducts in the crushing and transfer sections, and fines from the tower washers are treated in bag houses, cyclones, and settling chambers to recover dust.

Plant uses wide range of separation methods — Tables, Jigs, and Magnetic Separators









mine for fill, and a combined willemite-zincite concentrate which is shipped to Palmerton for zinc metal production.

Oversize from the House B screens is conveyed to Separator House A, where a series of screens produces five closely sized feeds which are distributed to 32 six-pole Wetherill separators. All of these separators produce franklinite for shipment. Eight, which handle the finest size feed, also produce half and half for shipment and the others produce middling which goes to recrushing rolls in Separator House B and then rejoin the feed for retreatment. The nonmagnetic product from each separator goes to a four-hutch jig, 32 in all, which produces willemite for shipment, middling which is dewatered and returned to the fine crushing department dryers for retreatment, and calcite tailing.

The smaller and more compactly housed Sterling Mill alternately handles two classes of ore, *brown* for separation into franklinite, willemite and calcite tailing as at Franklin, and *black* ore containing the so-called black willemite, a microscopically fine mixture of willemite and franklinite which cannot be liberated and is unacceptable in either the franklinite or willemite products. This class of ore is accordingly run separately through the mill crushing system and then dry ground to −28 mesh in a closed circuit ball mill and screen system for shipment to Palmerton as Waelz process feed.

Power and Shops Div.

Albert P. Mainka, Power Foreman at Franklin, is the author of this section.

THE power and shops div. consists of the boiler house, power house, hoisting engine house, and shops.

In the boiler house, two modern Sterling type boilers generate steam for the operation of turbogenerators, air compressors, hoisting engines, and plant heating. Each boiler is capable of generating 65,000 lb of steam per hour at 160 lb pressure and a final temperature of 485°F. They are equipped with chain grate stokers for burning No. 4 buckwheat coal, air preheaters and economizers, superheaters, forced and induced draft fans, and pneumatic type cinder and ash collection and disposal systems. A modern air activated control board is provided.

All water used by the boilers is treated by the hot lime-soda ash process to precipitate both temporary and permanent hardness followed by anthracite filters which complete the process of making a soft, clear, oxygen-free water. Some additional protective chemicals are added directly to the boilers to insure trouble-free operation.

In the power house, two 3750-kva, 3600-rpm, Westinghouse condensing turbogenerators supply power for both the Franklin and Sterling operations. Current at 460 v is supplied to a central switchboard for distribution to various parts of the mill, mine, and shops at Franklin. For delivery to Sterling, the voltage is stepped up to 11,000 and transmitted a distance of approximately 3 miles to step-down transformers at that point. A small amount of ac power is converted to 125 v dc for the Wetherill magnetic separators in the Franklin mill and to 250 v for mine haulage. Two 1500-kw, 1800-rpm, GE vertical turbines are available for standby service.

A tie-in with the local power company provides supplementary power for mine pumping and hoisting at Sterling.

Also in the power house, compressed air at 100 lb pressure is furnished by two large horizontal Corliss, cross compound condensing engines with tandem connected cross compound air compressors. Each compressor is capable of delivering 600 cfm.

The Palmer shaft hoist house contains two Allis-Chalmers duplex Corliss hoisting engines.

Both Franklin and Sterling operations have shops well equipped for the required wide variety of mine and surface plant maintenance and repair work. The shop crews also handle smaller structural steel fabricating jobs occasionally required.

Forestry Div.

Forestry Chief W. G. Bailey describes the activities of the Forestry Div. at Franklin-Sterling.

KEEPING the mines supplied with timber in sizes from 4 in. diam up, including 42 in. diam saw logs, is the main function of this division.

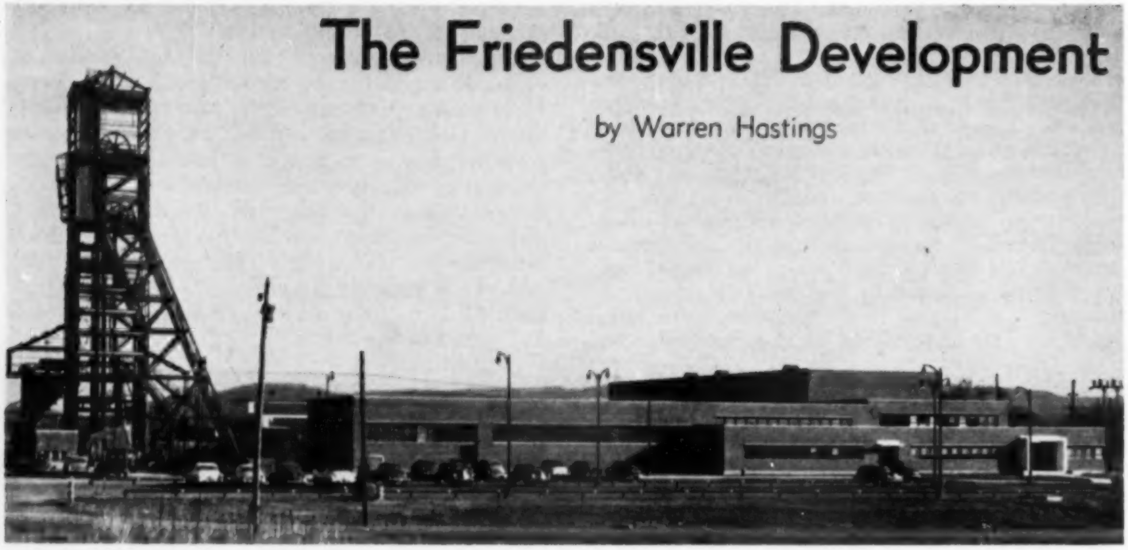
Under a sustained yield program which is the standard practice employed, only mature trees of 13-in. breast-high diam and up are removed on first cutting.

Such soft woods of smaller diameter as well as diseased, deformed or defective trees of any size containing usable lumber that the mines require also are removed.

Practically all cutting is done with one and two-man gasoline chain saws, and a tractor with track attachment treads and hydraulic draw-bar hoist does all the long heavy skidding, horses being used only to gather for the tractor in roughest places.

All road building and maintenance is accomplished with a shovel loader, the woods dump trucks and grader attachment on the tractor, making a completely mechanized logging operation.

The timber cutting program is based on at least a 20-year growth cycle before second cutting. This program has supplied mine timber for nearly 40 years and is expected to produce a consistent harvest sufficient to meet requirements for many years.



The Friedensville Development

by Warren Hastings

FOLLOWING 50 years of interrupted operation, when activity was limited to prospect drilling and hydrologic study, the decision was made in 1944 to reopen the property, despite the known difficulties to be encountered in handling excessive quantities of underground water.

Tentative plans for shaft location, underground operation, and surface layout were then originated, as influenced by evidence obtained by the extensive drilling program as to water and ground conditions.

Determination was made to locate the 20 ft 6 in. x 13-ft vertical shaft in the hanging wall of the orebody, as providing the least difficult location for mine access, although here too, intense rock weathering in depth was indicated by bore hole evidence.

Sealing off of ground water was first attempted by step drilling and grouting a ring of bore holes about the shaft site. This later proved ineffectual due to the impossibility of complete clay removal by washing previous to grout injection, the clay failing when subjected to unbalanced pressure occasioned by shaft advance.

No undue difficulty was encountered during the first 75 ft of excavation, but at that point water broke into the shaft.

A concrete plug was then cast at shaft bottom under balanced conditions of water pressure, water was pumped out, and after an extensive program of drilling and grouting from above the plug, sinking was continued.

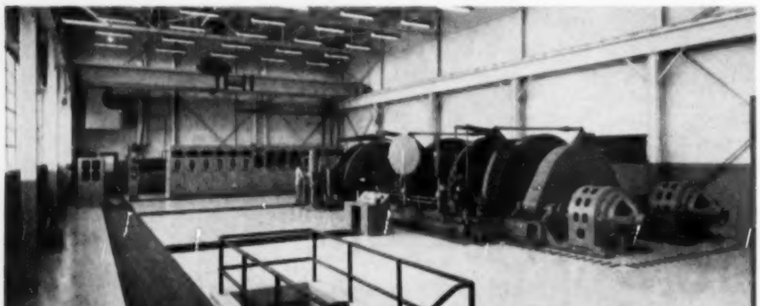
Twice thereafter breakthroughs occurred in the shaft and once during excavation of the 400-ft station, despite the elaborate drilling and grouting program carried in advance of all excavation.

Rock weathering was strongly in evidence throughout the greater portion of the shaft, and in the upper reaches structure was comparable to a rough masonry wall with bedding plane fractures dipping to the south and numerous cross fractures breaking the formation into roughly rectangular blocks, with clay filling the seams.

Water pressure of 530 psi was encountered at finished shaft depth of 1260 ft.

Shaft sets, consisting of 6-in. wide flange beams, are spaced on 7-ft centers, dividing the shaft into a central service compartment, two skipways, ladder, counterweight, pipe, and cable compartments. Shaft walls are heavily lined throughout with reinforced concrete which closely followed excavation. It is of interest to note that all concrete was delivered from surface through a 6-in. pipe without segregation of aggregate.

Shaft spoil was removed by a Riddell mucker delivering to a 50-cu ft sinking bucket.



Interior view of hoist house, which is part of unit service building shown in photograph at top of page. All services are housed in this U-shaped structure whose open side faces the shaft. Hoist house, with indoor substation, switchgear, service and ore hoists, forms one side; the east leg has supply storage and shops; the west leg includes offices, first aid, and change facilities.

Stations were turned off at approximate 100-ft intervals with bulkheads constructed at 75 ft from the shaft for protection against flooding during future development. Pumping stations and dual 390,000-gal sumps will be located beneath the 400 ft, 800 ft and 1050-ft levels, each serviced by five 3000-gpm pumps equipped for stage pumping.

Lowering of ground water is currently in progress through numerous bore holes radiating into the country rock and delivering to pump batteries located at depths of 418 ft and 600 ft. Discharge through a measuring weir delivers to two settling lagoons, each of 3.18 million gal capacity, previous to entry to the Saucon Creek.

To obviate undue interruption to operations, the permanent 132-ft, 200-ton headframe was erected on a temporary foundation and skidded into place on 80-lb rails by means of winch trucks serviced by triple and double blocks threaded with ¾-in. steel rope.

The shaft is equipped with a 65-man capacity double-deck cage operated in conjunction with a counterweight. Two 6-ton skips will deliver ore, which has passed through a primary 36x48-in. crusher located 1121 ft below surface, to the mill crushing department.

Favorable conditions of surface contour permitted the erection of all services at a common floor elevation in one U-shaped structure open toward the shaft, facilitating intercommunication, concentration of services, and reduced wall construction.

The hoist house, with full basement, contains the indoor substation, switchgear, service and ore hoists, compressors, boilers, and garage space. The east leg houses supply storage and all shops, while the west leg includes offices, first aid, and change facilities.

The initial housing development has been completed and it is anticipated that a total labor force of 400 men will be required for mine, mill, and services at production of 2500 tons per day.

Geology of the Friedensville Zinc Mine

by Robert B. Hoy

EARLY in the nineteenth century an unusual mineral was noted in the soil near Friedensville, Pa., in the Saucon Valley. However, it was not until 1845 that the mineral was identified as calamine and recognized as a potential source of zinc. Several attempts were made to mine the material in the next few years, and in 1853 successful production was begun at the Ueberroth mine. Production was more or less continuous until 1893, first from the Ueberroth mine, later from the Old Hartman, Triangle, Correll, and New Hartman mines. These operations were handicapped by ever-increasing inflows of water as they reached greater depths. In 1869 at the Ueberroth mine there was installed what at that time was reputed to be the largest Cornish pump in the world. The expense of pumping water proved so great that all the mines were forced to close in 1893 and have had no production since that time.

The New Jersey Zinc Co. first acquired property in Saucon Valley in 1899. Since that time several exploration programs were conducted and additional property was purchased. A new shaft was begun in 1948.

Robert B. Hoy is New Jersey Zinc's chief geologist for northeastern U. S.

Geology

Saucon Valley is a small (54 sq miles), elongated, oval-shaped basin within the Reading prong of the New England uplift. The valley has been eroded from Paleozoic limestones and shales which were down-faulted and folded into the surrounding pre-Cambrian gneisses.

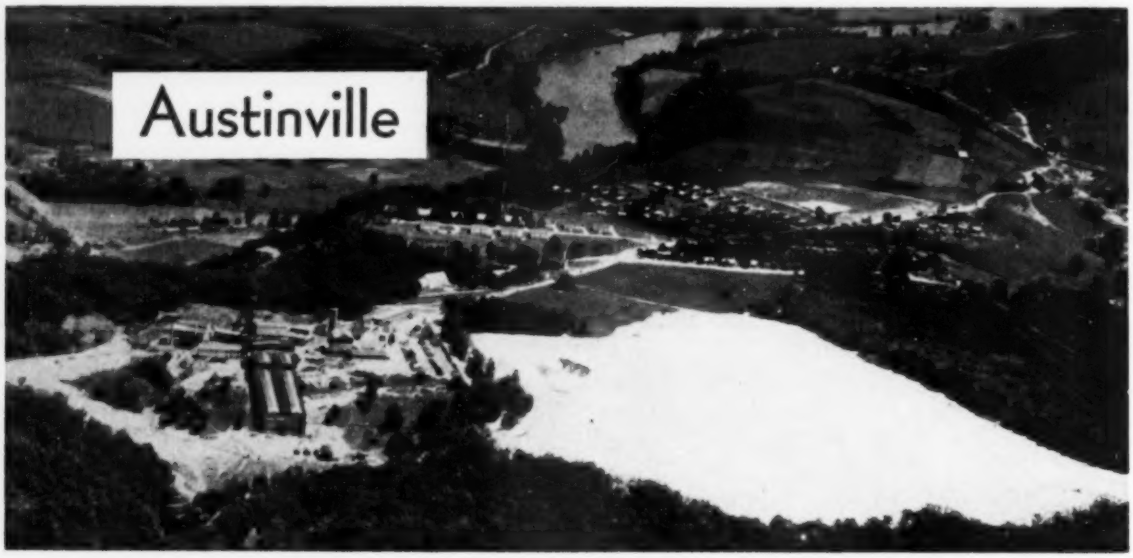
The Friedensville zinc mines all occur in the lower part of the Beekmantown formation of Ordovician age. They are associated with a westerly plunging, asymmetrical anticline, overturned to the north. The Ueberroth, which was the largest producer, is on the northwest vertical limb of the fold; the Old Hartman is on the crest; and the Correll, New Hartman, and Triangle mines are on the southerly dipping limb. The present development is on the south limb, a continuation from the Correll and the New Hartman mines.

The mineralogy is simple, consisting of sphalerite and pyrite with dolomite and quartz as gangue minerals. Much ore occurs as a replacement of the matrix of a breccia which is interpreted to be of sedimentary origin. Some ore also occurs as a filling and replacement along fractures of a *crackle* breccia. The Friedensville sphalerite is unusual in appearance, very much resembling the gray dolomite in which it occurs.

Oxidation reached to considerable depth in some of the mines. For example, at the Ueberroth mine, a large part of the 300,000 tons produced consisted of oxidized ore, the predominant zinc-bearing mineral being calamine (hemimorphite).

The Friedensville zinc deposits are of the Appalachian—Mississippi Valley type, the origin of which has not been conclusively demonstrated.

As to the age of the ore, the only definite statement that can be made is that it was deposited after Beekmantown time, because it replaces rocks of that age.



Rich in history, this property supplied lead to the Continental Army during the Revolution—to the Confederacy during the Civil War—and today supplies both zinc and lead to the New Jersey Zinc family of operations.

LOCATED on the New River, approximately midway between Bristol and Roanoke at the west foot of the Blue Ridge, the Austinville, Va., operation of The New Jersey Zinc Co., Bertha Mineral Div., has a rich historical background commencing with the first recorded ore discovery about 1750.

Early production was limited to mining *soft* or highly oxidized lead ore from relatively shallow open cuts. In Revolutionary days the mines in the district supplied lead to the Continental Army and were also the main source of lead for the Confederacy during the Civil War.

Originally known as Lead Mines the town was later renamed Austinville for Moses Austin, owner of the mines about 1785 and father of Stephen Austin for whom the capitol of Texas is named.

Although zinc mineralization was evident it was not until 1870 that recovery of both lead and zinc was attempted.

When the present operating company purchased the Wythe Lead & Zinc Mine holdings in 1902, Austinville presented many engineering problems. As mining increased in depth and the sulphide zone was encountered, the then existing methods of ore beneficiation were found to be unsuitable. Several years were consumed in experimentation, but it was not until the development of the flotation process that this substantial deposit was transformed into a commercial producer of zinc and lead.

Today, this operation, which has been worked continuously since its acquisition, employs approximately 625 people, many of whom live in Austinville, a completely modern community of 140 single family dwellings.

Above: W. L. Albers, Superintendent; Right: C. G. Morgenstern, Assistant Superintendent; both of the Austinville, Va., operations.

The Geology

by W. H. Brown

NEARLY all the zinc produced in Virginia has come from a small area 20 miles long and 5 miles wide in the southwestern part of the state, known as the Austinville Basin. Structurally, this is an overthrust, folded, fault block made up of an anticline on the south and a syncline on the north. The basin is overridden on the south by the great thrust along the northwestern base of the Blue Ridge and bounded on the northeast and west by the folded Laswell thrust fault.

The pertinent rocks in the area are sedimentary in origin. The basal group is known as the Chilhowie—a thick series of quartzites and shales of lower Cambrian age. Lying on the Chilhowie group is the Ribbon limestone member of the Shady formation. The Ribbon limestone, as its name implies, is an interbedded series of dark gray limestones and dolomites many of which have a pronounced ribbony texture. The wavy, ribbony bedding averages about 1 in. thickness. Resting conformably on the Ribbon is the Austinville dolomite member of the Shady formation. This is a predominately massive, light gray, saccharoidal rock, from which the bulk of the production in the district has been derived. Resting on the Austinville dolomite is a bed of very pure limestone called the Carbide limestone for its use in the carbide industry. To the north of Austinville, the Rome formation, composed of dolomite interbedded with red shale rests on the Carbide, but to the south, the horizon above the Carbide limestone consists of a considerable thickness of interbedded limestone and dolomite whose correlation is in doubt. It has been called the Mystery series for lack of a better name. Other names for the members of the Shady have been proposed by Currier.[1]

[1] Currier, L. W.: Zinc and Lead Region of Southwestern Virginia. Va. Geol. Survey, Bull. 43, pg. 16, 1935.

At Austinville this series of beds is folded into an anticline complicated by faulting. The cross-section on the drawing shows some of these features.

The Austinville Orebodies

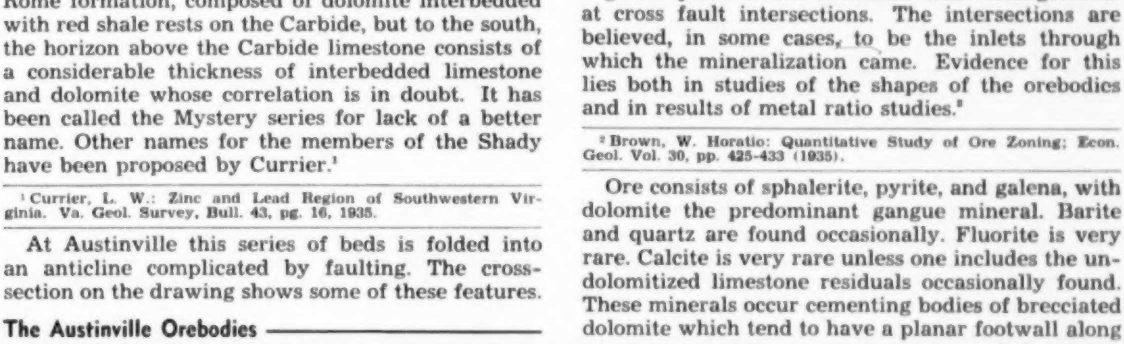
W. H. Brown, Geology Chief, examining drill core. The author points out that all surface drill core is carefully preserved and termed "a most important reference library."

An approximately vertical strike fault with south side down is found close to the anticlinal axis. About 1200 ft south there is a nearly parallel reverse fault. Nearly all of the production of the district has been derived from the block between these two faults. The saccharoidal dolomite within the block has a fairly uniform southeasterly dip of approximately 30° and is broken by a rather complicated series of strike faults, bedding plane thrusts and cross tears.

The ore occurs as lenses along the bedding on or paralleling the system of minor strike faults and has a gentle pitch to the northeast with enlargements at cross fault intersections. The intersections are believed, in some cases, to be the inlets through which the mineralization came. Evidence for this lies both in studies of the shapes of the orebodies and in results of metal ratio studies.[2]

[2] Brown, W. Horatio: Quantitative Study of Ore Zoning; Econ. Geol. Vol. 30, pp. 425-433 (1935).

Ore consists of sphalerite, pyrite, and galena, with dolomite the predominant gangue mineral. Barite and quartz are found occasionally. Fluorite is very rare. Calcite is very rare unless one includes the undolomitized limestone residuals occasionally found. These minerals occur cementing bodies of brecciated dolomite which tend to have a planar footwall along



the bedding and extend upward, gradually dying out in the overlying rocks. Four principal textural types of ore are found: mosaic breccia, which is the most abundant type; rubble breccia, which is much less common; rosette ore, which forms the highest grade ore and tends to occur along the footwall of orebodies; and disseminated ore.

Associated with the orebodies are large amounts of recrystallized ground. At Austinville the process of recrystallization has been much more intense than in other Appalachian districts. This strongly recrystallized ground tends to occur as a shell around the orebodies on all sides except the footwall and is a valuable guide in prospecting. The deposits are believed to be of low temperature hydrothermal igneous origin, probably derived from the late Paleozoic granites known to the east.

Geologic work has been carried on since about 1907, and during the earlier years, most of the work was done by the late F. L. Nason. Since 1927, geologists have been in residence and given continuity to the job.

All surface drill core is preserved and regarded as a most important reference library. Some success has been had in tracing ore electrically[3] and the geochemical prospecting techniques[4] used by the company were in part developed here.

[3] McMurray, H. V., and Hoagland, A. D.: Three Dimension Applied Potential Studies: Presented at Roanoke Meeting GSA, May, 1952 and now being prepared for publication.

[4] Fulton, R. B.: Prospecting for Zinc using Analysis of Soils: Econ. Geol. Vol 45, pp. 654-670 (1950).

Today the work of the geologic staff is threefold: 1—It is headquarters for regional exploration. 2—The department has charge of exploration, both on surface and underground and assists the mining dept. with problems involving ore extraction. 3—The department, to a considerable extent, is a training school for young geologists.

Mining at Austinville

by A. C. Savage

AUSTINVILLE mine is serviced by a five compartment, 1250-ft vertical shaft. A three compartment, 650-ft vertical service shaft located 1½ miles northeast of the main shaft was recently completed.

Owing to the presence of numerous underground faults and fractures which are often heavily water-bearing, all drift and raise work in undeveloped and undrained areas is preceded by pilot drill holes and grouting where necessary. Geological and water contour maps, the data for which are obtained from surface drill holes, also serve to indicate where hydrologic problems may be encountered. Steel bulkhead doors are installed throughout the mine for protection against heavy inflows of water.

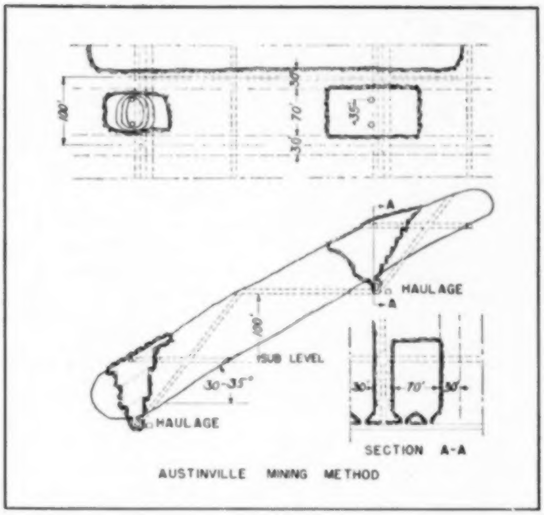
Automatic feed 3½-in. drifters mounted on Joy two-drill jumbos, 1¼-in. round steel, and Timken detachable bits, are standard equipment for driving the 8x10-ft haulage drifts. Twenty-eight to 32 holes are required to break the 9-ft burn cut round. The two top corner holes serving as pilot holes are drilled to a depth of 16 ft, the first 9 ft being fired.

Raises, 5x5 ft, are drilled from staging supported by steel pins. A 17-hole burn-cut round, 7 ft long, is drilled with Ingersoll-Rand R-91 stopers, 1-in. hexagon steel, and Timken detachable bits. One 12-ft hole serves as a pilot hole.

The mining method can be described as underhand open stoping. Orebodies strike northeast and dip approximately 35° southeast. Pillars 30 ft in width are spaced on 100-ft centers along strike, leaving a stoping width of 70 ft. Dip length of stopes averages about 150 ft between levels and ore thickness varies from 30 to 100 ft.

Stopes are developed by raising two chute holes, 35 ft apart, to the footwall of the ore where grizzly chambers are excavated. Manway raises on the opposite side of the haulageway are connected to the grizzly chambers with short drifts. Service raises, located at 200-ft intervals and in the center of the

Left: The underground transformer station and automatic pump controls are provided in a clean, well-lighted operating room. Right: A. C. Savage, Mine Chief.



pillars, connect the haulageway with crosscuts to the hanging wall, driven from the haulageway above. Openings from the service raise provide access to the stopes on either side.

After the chutes, grizzlies and ladderways are installed, stoping is started in the chute raises by enlarging each drawpoint in the shape of an inverted cone until these openings connect.

From this point of connection, a column-mounted drifting machine is used to drive a spiraling bench to the stope hanging wall. A breast is then carried across the stope from pillar to pillar and up dip in advance of breaking the underlying ore by benching with 3-in. hand-held sinker drills, equipped with spring handles. Benches are drilled 10 ft deep and the breaking face carried to a depth that provides a slope sufficient for broken ore to run to the draw points. To extract the remaining ore and clean the stope footwall, slushers are employed.

Approximately 50 pct of the dip pillars are recovered by the removal of sections, the length of which is dependent on ground conditions. The section to be mined is first cut loose at the hanging wall and then broken by benching as in the stoping operation. Ore extraction approximates 85 pct.

The ore, after passing through a grizzly with 10 ft x 13-in. openings, is loaded from the chutes into 1¾-ton cars and hauled in 12-car trains by 4-ton Edison battery locomotives to an ore pass, where the cars, two at a time, are dumped by air-operated rotary dumps. By finger gate control at the bottom of the ore pass, the ore is fed onto a grizzly which allows the −5 in. material to pass directly into a 500-ton ore pocket. Oversize is reduced to 5 in. by a 30x42-in. Buchanan Blake type crusher driven by a 100-hp type KR wound rotor motor through a gear reducer.

The crushed ore is automatically measured and loaded into 6-ton skips which are hoisted in balance.

The mine, employing approximately 300 men and operating on a 3-shift basis is presently manned to produce 2400 tons per day.

Milling and Service

by J. I. Craig

THE present mill, consisting of two duplicate units, was started in 1927 with a capacity of 1000 tons daily. After several stages of expansion and changes of the flow sheet, the mill is currently treating more than 2400 tons of ore daily. The two principal products are zinc and lead concentrates, with the tailing being prepared and disposed of as agricultural limestone.

The ore as mined runs approximately 4 pct zinc, 1 pct lead and 2.25 pct iron in grade, with a 2.9 sp gr.

The mine crushed product hoisted in 6-ton skips is conveyed to 750-ton silo type bins at the head of each unit. Tramp iron is removed by two 40-in. Ohio electromagnets, with other foreign materials removed by hand.

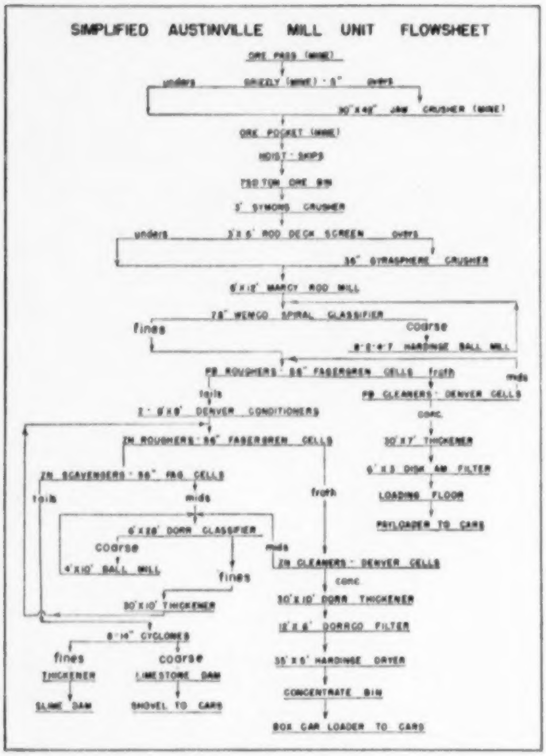
Ore is removed from the bins at a rate of 50 to 55 tons per hr by a 36-in. pan feeder, discharging to a 3-ft Symons standard cone crusher provided with extra coarse bowls set at 1¼ in. The crushed product is carried over a Merrick weightometer on an 18-in. belt conveyor and after passing under an electromagnet and over a magnetic head pulley, is delivered to a 3x6-ft Symons Rod Deck screen with 5/16 in. openings. The rate of feed to the Symons crusher is automatically maintained by the weight of material passing over the weightometer.

Screen undersize drops onto a 24-in. conveyor belt below the crusher and the oversize is delivered to a 36-in. Telsmith Gyrasphere crusher which reduces it to −⅜ in. The crushed product joins the screen undersize and is transported to the feed chute of an 8x12-ft Marcy rod mill.

The entire grinding section of the mill has recently been completely rebuilt to increase its capacity and efficiency and decrease costs. At present more than 50 tons per hr can easily be handled at a power consumption of 9 to 9.25 hp-hr per ton when reducing ore from −5/16 in. to 20 to 25 pct +100 mesh.

The 8x12-ft Marcy rod mill, operated on water-lubricated Micarta trunnion bearings, is driven at 16.3 rpm by a 350-hp type KG motor through a Falk gear reducer. The mill, charged with 73,000 lb of 3-in. max diam rods, is equipped with Lorain type lining. The −5/16 in. ore is fed to the mill through a chute feeder and is reduced to 100 pct −10 mesh. The pulp discharges through a screen trommel attached to the rod mill, and by means of a 6-in. rubber pipe, is carried to a 78 in. x 25 ft 6-in. spiral classifier, operating in closed circuit with a Hardinge Tricone ball mill, running on water-lubricated Micarta trunnion bearings at 20.5 rpm. This mill, equipped with a cast dipper, is lined with cast Ni-Hard blocks. The unit carries a ball charge of 38,500 lb and is driven through a Falk reducer by a 200-hp type KG motor. Reagents added during grinding are creosote and Aerofloat 25.

The classifier overflow is maintained at 40 pct solids by manual control, aided by continuous recording of overflow pulp dilution.



Pulp is passed directly to the first cell of two 6-cell banks of 56-in. Fagergren flotation cells. Sodium silicate is added at the start of lead flotation. The froth from the 12 rougher cells is pumped to the first lead cleaner made up of three No. 21 Denver Sub-A cells. The froth from the first cleaner is laundered to a single No. 21 Denver Sub-A cell acting as a final cleaner. Middling flows by gravity to No. 1 rougher. Lead concentrates are piped 3000 ft to a 30-ft thickener located in the rail loading and shipping area. Thickened concentrate is filtered on a 6-ft disk type American filter and stored on a concrete floor from which it is transferred to railroad cars by a Hough Payloader.

The tailing of the lead section, at approximately 35 pct solids, has copper sulphate added and is conditioned in two 8x8-ft Denver conditioners in series. Pine oil and additional Aerofloat 25 are added to the pulp which passes through four banks of six 56-in. Fagergren cells. The froth from the first two banks is sent to the cleaner section and the froth of the last two banks joins the middling product which is returned for regrinding in a 4x10-ft ball mill. The reground middling product is thickened and returned to the head of the first rougher.

The froth sent to the cleaners is split. Each half is sent to a bank of three No. 21 Denver Sub-A cells operating as the first cleaner, with froth passing to a single No. 21 Denver cell operating as the second cleaner. Middling counterflows the froth throughout the cleaning circuit.

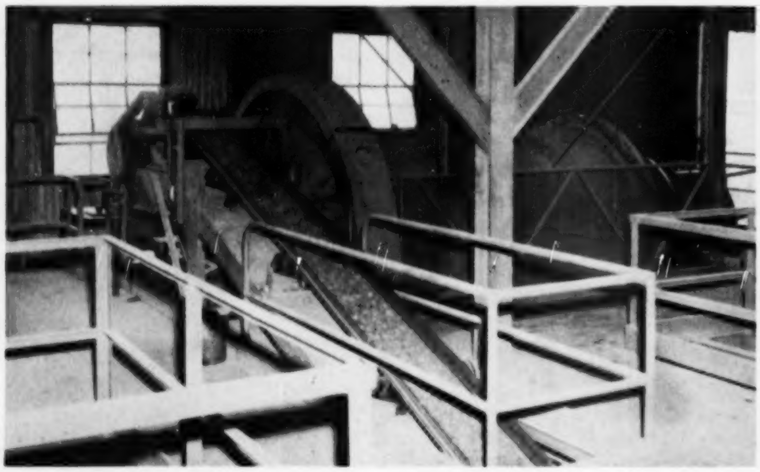
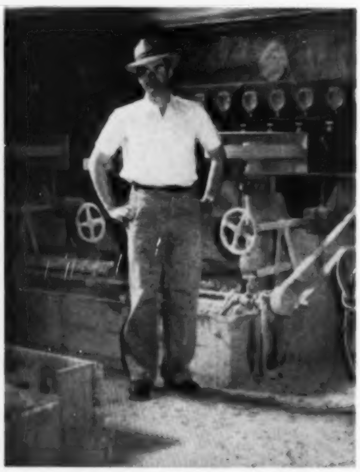
The final zinc concentrate is pumped to the same area where the lead concentrate is filtered. Filtering is accomplished on a 6x12-ft Dorrco filter after thickening in a 30-ft thickener. The cake is dried to about 3 pct moisture in a 5x35-ft Ruggles-Cole drier, rotating at 7 rpm and fired directly with a Skelly type stoker. The dried concentrates are stored in a 300-ton silo type bin.

The tailing produced in the mill is processed through a battery of 14-in. hydrocyclones to remove slime prior to being piped by gravity to stocking sites adjacent to railroad shipping facilities. The slime overflow of these classifiers is pumped to a disposal site 3500 ft from the mill where an impounding area is maintained behind a dam built from the tailing.

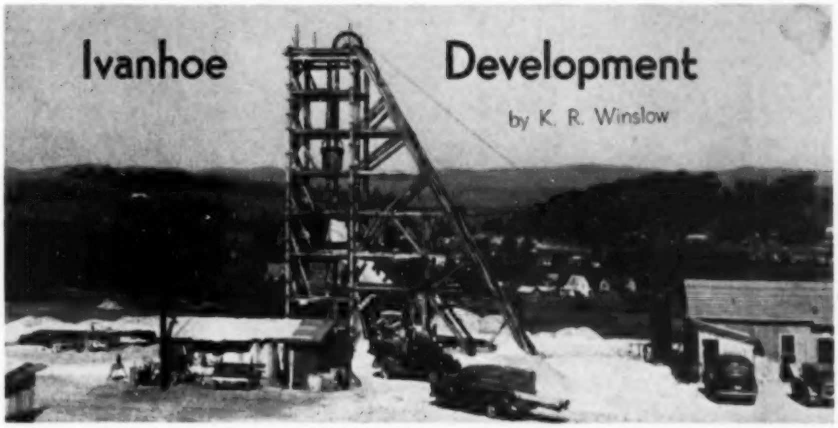
Service Facilities

Due to the geographic location of Austinville, it is necessary that service facilities make the property self-dependent for maintenance. The power and shops div. is responsible for power supply and all shops except carpenter shop. Facilities include electrical div., machine shop, and the blacksmith shop which builds all mine cars, skips and 2½ ton battery locomotives in addition to usual tasks. There is provided a plant engineering div. and a yard service div.

The community was rehabilitated in recent years, with new water system, fire protection system, sewage facilities, modernized and enlarged dwellings, and surfaced streets and street lighting were extended throughout the camp.

Left: This 8x12-ft Marcy rod mill is a primary grinding unit in the Austinville flowsheet. Right: J. I. Craig, Plant Chief.



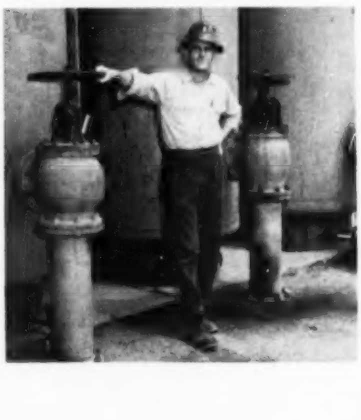
This sinking headframe and hoist house were used to sink the 1050-ft shaft to open up this new mine. Ore will be trammed through a 14,000-ft tunnel to the Austinville property, where it will be milled.

ONE of the New Jersey Zinc mines currently being developed lies 2½ miles southwest of the Austinville operation. Prior to 1947, when an exploration program was initiated in the Ivanhoe area, desultory mining of oxidized lead and zinc ore at relatively shallow depths had been practiced by several operators. During the 1920's and 1930's, the area was diamond drilled by other mining companies without sufficient success to justify further development.

Diamond drilling by the company indicated a grade and tonnage of zinc-lead sulphide ore sufficient to justify underground development. Accordingly, plans were instituted to sink a three-compartment vertical shaft, 12 ft 6 in. x 14 ft in cross-section, and 1050 ft deep. In January 1952, after a 1096-ft hole was diamond drilled from the surface on the approximate center line of the proposed shaft site to determine the hydrologic and geologic conditions which might be encountered, the first ground was broken for the new shaft. Construction of the permanent concrete shaft collar on solid rock at a depth of 35 ft and the erection of the temporary timber headframe and building to house a single drum 200-hp, 600-fpm sinking hoist, an Ingersoll-Rand XLE compressor, and change facilities followed.

During April 1952, full scale sinking operations in the dolomitic limestone were commenced on a three-shift, seven-days-per-week, schedule. Each of the three shaft crews consisted of 7 men: 5 shaft men, 1 hoistman, and 1 shift foreman—all of whom were on an incentive plan.

Sullivan LM 57 sinkers with 1¼-in. alloy intraset drill steel were used for shaft drilling. Four drills were operated, drilling a 48 hole V-cut in approximately 1 hr and 45 min. All holes were drilled 6 ft except the 4 ft Baby V and 8 ft V-Cut holes. Blasting was done electrically with standard delay caps and 40 pct semigel powder. Powder consumption was approximately 28 lb per ft of advance.



K. R. Winslow is Ivanhoe General Foreman.

Mucking was done with a ⅜-yd Blaw Knox clamshell, operated by two Gardner-Denver HKL air hoists fastened to the bottom set and kept a minimum of 50 ft and a maximum of 190 ft above the shaft bottom. Ninety-nine pct of all rock was loaded mechanically. The 50-cu ft sinking bucket was dumped into a Mack A-40 dump truck at the surface, where the waste rock was utilized in building a yard and roads.

A scaffold constructed of 4-in. channel beams, covered with 2-in. plank and supported by six ½-in. cables, was used for all timbering. The shaft was timbered in 100-ft sections with 8x8-in. oak dividers, set on strike at 5-ft vertical centers. Cage and counterweight guides were 6x8-in. pine and 40-lb rail respectively.

Nine stations, 9x16-ft cross-section, were driven off the shaft, 50 ft along strike in each direction. Drilling was done with column-mounted drifters, with broken rock moved to the shaft by a double drum slusher.

A Joy 20-hp Axivane fan with 20-in. vent pipe provided excellent ventilation.

Water flows requiring grouting were encountered three times. Maximum water in the shaft bottom was 25 gpm which was pumped by I-R 35 air pumps to 20-hp electric relay pumps.

The shaft was completed in April 1953. Excellent progress and efficiency, as indicated by the completion of the 1050-ft shaft and stations in approximately one year, were reflected by favorable costs.

Open stoping will be used at Ivanhoe with the probable use of either diamond or percussion drilled long bench holes. Blasting will be done electrically, using MS delay caps for greater fragmentation.

Haulage on the intermediate levels will be with 7-ton battery locomotives, and 80-cu ft Granby type cars. Ore from Ivanhoe will be trammed underground to Austinville for milling. Ten-ton diesel locomotives and 80-cu ft rotary dump cars will be used for this service. Work is in progress on the 14,000 ft of 8x10-ft haulage tunnel which will connect the two properties.

The shaft will be serviced by a 200-hp 9-ft diam single drum Nordberg hoist grooved for 1½-in. rope, operating a 6 ft 6 in. x 12-ft counterbalanced man cage. In addition to the hoist and two I-R XLE compressors, the permanent hoist building will house change facilities, mine office and a maintenance shop.

New Jersey Zinc

The Eagle Mine

Mine-in-a-canyon is the word description of this prolific zinc producer high in the Sawatch Range. Terrain helped dictate the unusual location of the flotation plant — underground.

THE Eagle mine of the Empire Zinc Div. of The New Jersey Zinc Co. is 76 miles west-southwest of Denver, at Gilman. This modern mining community, with a population of about 325, is on the western side of the Continental Divide, at an elevation of 9000 ft on the flank of Battle Mountain. According to legend, Battle Mountain gained its name from a battle between the Ute and Cherokee Indians. The Eagle River flows through a steep canyon, approximately 600 ft below the town. Gilman is served by U.S. Highway No. 24 and the D&RGW railroad which runs through the canyon. Approximately 550 persons are employed at the Eagle mine, many of whom live in nearby Minturn and Red Cliff.

The Eagle mine organization consists of four departments: mine, mill, engineering and geology, plant and service. Property examinations and exploration activities for the central Rocky Mountain area are conducted from Gilman.

Mineral deposits of the Battle Mountain district were discovered in 1879 by the overflow of prospectors from the Leadville area. First discoveries were of rich oxidized silver and base metal ores, and gold ores. The area developed rapidly and nearly all of the productive properties were discovered within the first 5 years. As the depth of mining increased the sulphide zone was reached, and zinc became increasingly abundant. Later, copper-silver ore was discovered in funnel-shaped chimney deposits, near the down dip ends of the zinc bearing mantos.

The Empire Zinc Co., a subsidiary of The New Jersey Zinc Co., became interested in the district in 1912, and by 1915, acquired the larger mines in the area, which were consolidated into the Eagle mine. The property has been worked continuously since its acquisition. An underground flotation mill for the concentration of the zinc ores was constructed between 1927 and 1929. Zinc ore has constituted the major production from the area, except for the period between 1931 and 1941 when copper-silver ore was intensively mined.

The district has, for a number of years, been one of the leading producers of base and precious metals in the state.

The staff at Gilman: (left to right) Harold Stienmier, Plant Chief; J. G. Craig, Mill Chief; F. J. Maloit, General Superintendent of the Empire Zinc Div.; W. L. Jude, Superintendent of Gilman operations; R. E. Radabaugh, Geology and Engineering Chief; R. L. Sayrs, Mine Chief.

Geology and Ore Occurrence

by R. E. Radabaugh

THE Battle Mountain district is on the northeast flank of the Sawatch Range. The rocks of the area consist of a thick series of Paleozoic sedimentary strata resting on a basement of pre-Cambrian intrusives and metamorphics. The sedimentary formations range in age from Cambrian to Pennsylvanian. A sill of Tertiary quartz latite porphyry has been intruded a few feet above the contact between the Mississippian and Pennsylvanian strata.

The sedimentary rocks strike northwesterly and have a rather uniform dip of 10 to 12° to the northeast, away from the Sawatch uplift. The main structural features are zones of small, discontinuous, high angle faults; bedding plane faults; and small, relatively sharp folded structures. Some of the high angle faults are the result of a reduction in volume accompanying the mineralizing process. The exact structural control of the orebodies is not well defined, although structures in the pre-Cambrian basement are believed to be of importance.

The Mississippian Leadville limestone, the main ore bearing horizon, was completely dolomitized by hydrothermal solutions during the early stages of the mineralization. Recrystallization, leaching, and solution accompanied the dolomitizing process developing sanded rock, rubble filled channels and banded *zebra* textures. The sanding results from the removal of the cementing bond between the individual grains and is found in all degrees of intensity. Clay mineral alteration halos are present around the orebodies.

The ore deposits of the Gilman district consist of fissure veins in the pre-Cambrian rocks and the Cambrian Sawatch quartzite, and replacement deposits in the quartzite and in the Devonian Chaffee formation and Mississippian Leadville limestone. The fissure veins contain pyritic gold and complex sulphide ores. They are small and of only minor importance at the present time.

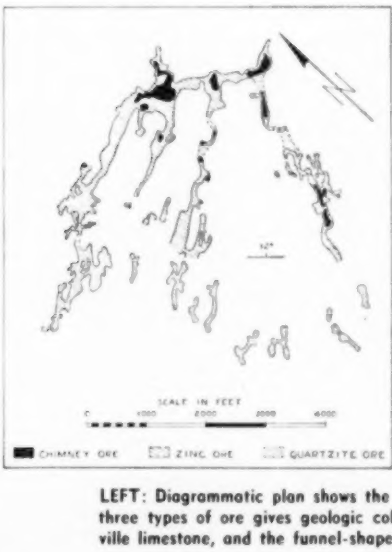
The replacement bodies in the quartzite consist mainly of pyritic gold-silver-copper ore, although some small bodies of zinc and lead sulphides have been found. The greatest production from these orebodies came from oxidized portions near the surface.

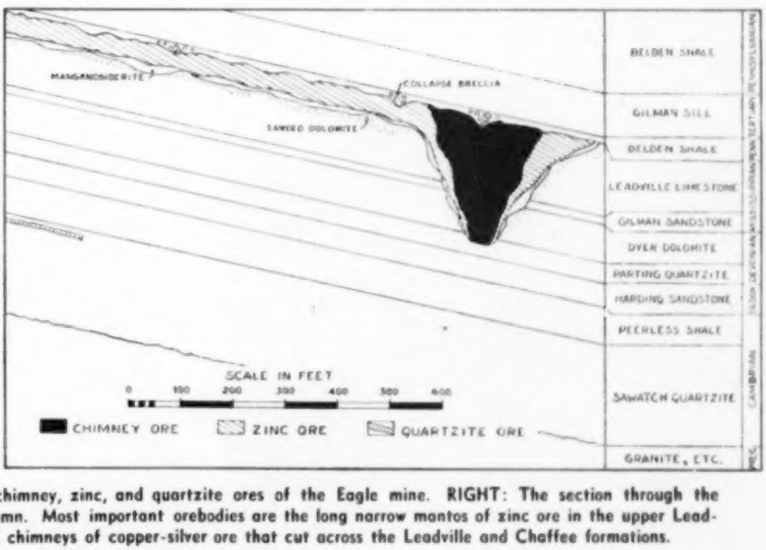
The most important orebodies are replacement deposits in the carbonate rocks. They consist of long, relatively narrow mantos of zinc ore in the upper portion of the Leadville limestone, and funnel-shaped chimneys of copper-silver ore that cut across the strata of the Leadville and Chaffee formations. The mantos and chimneys are arranged roughly in the shape of a trident that points up dip. Its three prongs are formed by the mantos that turn sharply downward near their downdip extremities to form the chimneys. The chimneys are connected across the base of the trident by short mantos, the long axes of which are roughly parallel to the strike of the beds.

Mineralization is continuous from the chimneys into the mantos, but there is a marked difference in the mineralogy of the two types of bodies. The principal minerals found in the copper-silver bearing chimneys are chalcopyrite, tetrahedrite, freibergite, and occasional galena in a gangue of pyrite. The commercial mineralization in the chimneys is erratic, and considerable portions consist of almost barren pyrite. The chimneys are surrounded by thin but more or less continuous shells of zinc ore, manganosiderite, and sanded dolomite.

The manto orebodies are largely zinc ore, although some of them contain a core of barren pyrite near the lower end. The mantos are surrounded by shells of manganosiderite and sanded dolomite.

The most abundant minerals found in the mantos are sphalerite (marmatite variety) and galena in a gangue of pyrite and manganosiderite. The average marmatite contains approximately 54 pct zinc and





LEFT: Diagrammatic plan shows the chimney, zinc, and quartzite ores of the Eagle mine. RIGHT: The section through the three types of ore gives geologic column. Most important orebodies are the long narrow mantos of zinc ore in the upper Leadville limestone, and the funnel-shaped chimneys of copper-silver ore that cut across the Leadville and Chaffee formations.

11 pct iron, and some of it may carry fractional percentages of lead and copper. The latter two metals occur as microscopic inclusions of galena and chalcopyrite.

There is a wide variation in the physical characteristics of the ores. They are classed as bed rock ore, rubble ore, and sand ore. The bedrock and rubble ores are generally relatively hard and tough, whereas the sand ore is quite friable and poorly consolidated. Frequently it will not stand without support.

The shale and porphyry cap rock swell when exposed to the air. This swelling together with a collapse breccia, formed by the slumping of the shale and porphyry into voids in the top of the ore, create heavy ground which requires timber support.

The ores oxidize rapidly on exposure to the mine atmosphere, and thin films of the oxidation products coat the individual grains and penetrate into minute fractures. Soluble salts — mostly the sulphates of zinc, magnesium, copper, and iron — develop rapidly after the orebodies have been opened.

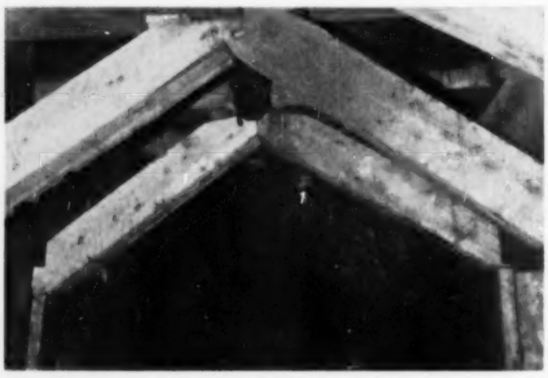
Mining Operations

by R. L. Sayrs

Mucking machine operating on 11° incline.

TYPES and mineral content of the ores making up the Gilman orebody require a selective system of mining. At the present time, all stoping at the Eagle mine employs square-set or modified Mitchell timber and fill methods. There are, however, certain orebodies that lend themselves to alternate cut and fill stoping.

Square-sets are 5x5 ft and 7 ft 10 in. high and produce about 25 tons per set. Posts and caps are 10x10 in. and collar braces 7x10 in. in section. Thin ore, i.e. 8 to 24 ft thickness, is usually mined by square-sets; whereas the thicker ore sections are mined by modified Mitchell sets. Square-sets are used on the top floor of all modified Mitchell stopes due to the heavy, swelling type of cap rock. Modified Mitchell sets differ from square-sets only as to length of caps, which are 10 ft long, and produce 50 tons of ore. The top floor square-sets are supported by arch-braced modified Mitchell sets on the floor immediately below. Practically all timber is purchased locally, about 15 board ft being required for each ton of ore mined.



Arch-braced, modified Mitchell sets 10 ft long support the top floor square-sets.

Stoping is underhand, with the exception of the cut and fill stopes, because of the loose and heavy type of ground. Some ore blocks require carrying the top floor advanced one set ahead of the rill in order to control running ground.

Stopes are usually 10 ft wide, 100 ft high, and 50 ft long. When mined out, the stope is lagged inside the ore wall posts, and filled with waste rock. Open sets below the level are filled by tramming, and those above the fill drift are caved, pulling the waste cap rock from over the adjacent, previously filled stope. All development waste rock is used for stope fill. Mill tailing cannot be used due to its extremely high sulphide content, approximately 70 pct, which would create additional fire hazards.

Gardner-Denver S-33 jackhammer rock drills, with ⅞ in. hexagon carbon steel and Portland Throwaway bits are used in all stoping operations. A few air-legs are in use. However, due to the softness of most stoping ground, these drills have not been thoroughly accepted by the miners.

Direct stoping efficiencies vary from 4 to 10 tons per manshift with a few stopes up to 15, depending

on the type and thickness of the ore. These figures are based on complete stope cycles, including fill.

All development headings are driven 8x8 ft in section at a rate of about 1.80 ft per manshift. Crews are made up of two men per shift who do all work connected with advancing the heading including haulage, pipe and track. Standard equipment is either Joy Hydro drill jib, or Cleveland air-operated boom, two-machine jumbo with Eimco No. 21 mucking machines. Drills are Gardner-Denver CF 89 drifters using 1⅛-in. round, hollow carbon steel with Portland Throwaway bits.

Inclines have been *sunk* with inclinations up to 18° by use of mucking machines without cable reels, taking advantage of friction only for movement of the machine on the rails. Track throughout the mine is 24-in. gage, 30-lb rail, with the exception of main haulage to the mill which has 45-lb rail.

During the past 20 years, the Gilman mine has had three fires of spontaneous nature caused mainly from oxidation in old, inaccessible mined areas. The first fire was extinguished by flooding the mine, which proved to be both expensive and inconvenient. The two more recent fires were extinguished by sealing off the fire area by means of gunited fire seals. This method proved to be far better inasmuch as the balance of the mine was available for mining operations. As soon as the atmosphere behind the seals indicated absence of carbon monoxide and sufficient time had elapsed for cooling, the areas were opened and mining resumed immediately. The present method of preventing mine fires is to fill old, mined out sections with slimes produced by grinding development waste rock and pumping them into those areas.

Ventilation throughout the mine is maintained by means of a Jeffrey two stage 8H-60 Areodyne fan exhausting approximately 110,000 cfm. This fan is powered by a General Electric 250 hp synchronous motor. Capacity may be increased to 150,000 cfm by a simple adjustment of the blades. Good air circulation is important from the standpoint of fire prevention, in that the circulating air tends to cool the heating sections of the mine. Ventilation doors, both hand and automatically operated, are used for control of this circulation.

Packaged timber handling effects economies for Eagle mine, where about 15 board ft of timber is required per ton of ore mined.

The mine produces about 1000 tons of zinc ore and 150 tons of copper-silver ore per day; is operated on a 3-shift basis, 5 days per week, and employs approximately 340 men. Copper-silver ore is loaded directly into railroad cars for shipment to smelters, and the zinc ore is milled at Gilman.

The Underground Mill

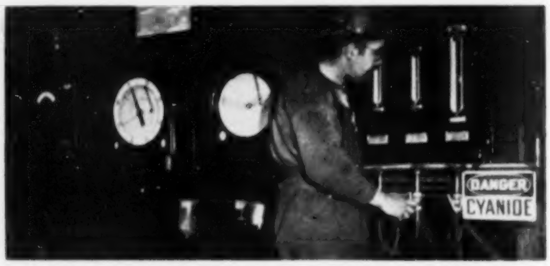
by J. G. Craig

GILMAN MILL, one of the few underground beneficiation plants in the world, normally treats 1000 tons per day of lead-zinc ore.

Ore is received from the mine at 12-in. max size and crushed in a 24x42-in. Birdsboro-Buchanan jaw crusher to 3-in. size, then further reduced to ½ in. in a 4-ft Symons standard cone crusher. The crushing plant has a capacity of 150 tons per hr and all crushing is done on a two-shift basis because there exists ample coarse and fine ore storage capacity. A 10,000-cfm Rotoclone dust collector aids in the control of dust in the underground crushing room.

The ore is washed ahead of grinding by a two-stage Dorr classifier in order to minimize the variables induced by a relatively large amount of soluble metallic sulphates present in the ore. In this washing process a slime portion is produced containing about 10 pct of the feed weight and about 90 pct of the soluble salts. Approximately 50 pct of the relatively coarse solids in this slime product is returned to the grinding circuit through the use of two 6-in. hydrocyclones, while the balance of the fines is treated separately in a battery of 8 No.36 Agitair flotation cells. These cells, operating in a natural slightly acid pH, require only a small amount of collector and frother to produce a bulk lead-zinc float. A product containing approximately 90 pct of the zinc entering these cells is recovered here and sent to conditioners ahead of lead flotation. The use of the hydrocyclones in the slime circuit has resulted in substantial improvement in over-all zinc recovery.

The coarse washed ore is ground in two stages with 4x10-ft Marcy rod mills and 6x6-ft Eimco ball mills and classified in 54-in.Akins classifiers to a −65 mesh product. With the change to two-stage grinding from rod milling, greater capacity was ob-



Cyanide solution feed rate is measured on the Flowrators. Automatic pH control and control of copper sulphate are provided at this lead section instrument panel.

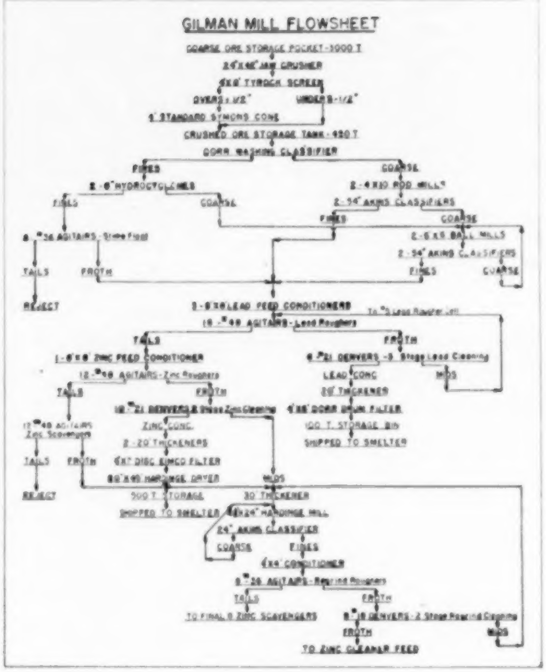
tained with less power and reduced grinding media and liner wear. Warm water piped from the mine at 80°F and 7.2 pH is used in the grinding section to obtain the proper flotation temperature.

The ground pulp is conditioned in three 8x8-ft Wemco conditioners for about 25 min with lime and cyanide ahead of lead flotation to depress the pyrite and marmatite. The lead rougher concentrate from 16 No.48 Galigher cells is cleaned in three stages in 6 No.21 Denver flotation machines to a final lead product which is thickened in a 20 ft diam Hardinge thickener and then filtered in a 6-ft diam x 4-ft Dorr internal drum filter to about 8 pct moisture and shipped to outside smelters.

Typical Assays and Distribution of Circuit Products

Product	Assays pct Zinc	Assays pct Lead	Distribution pct Zinc	Distribution pct Lead
Mill Feed	11.0	1.7	100.0	100.0
Lead Concentrate	4.0	65.0	0.7	80.3
Zinc Concentrate	50.0	0.50	94.0	6.1
Tailing	0.75	0.30	5.3	13.6

The lead tailing is conditioned for 8 min with copper sulphate, lime, and collector ahead of zinc flotation. Zinc rougher concentrate from 12 No.48 Galigher cells is cleaned in two stages in 10 No.21 Denver machines to a final zinc product which is thickened, filtered, dried to about 3 pct moisture, and shipped to company smelters. Additional flotation machines in zinc scavenger and zinc middling



regrind circuits aid in obtaining maximum zinc recovery.

Final mill tailing containing about 70 pct pyrite is carried by pipe line down the Eagle River Canyon, about 3.5 miles, to a flat area where they are impounded behind a dam. The dam is continually built by dropping coarse tailing at intervals from the pipe line. The clear water, after solids have settled out, is decanted from the pond and returned to the drainage system.

The control of pH in the lead section(pH 9.0) and in the zinc section (pH 10.5) is automatic, through the use of two Brown-Beckman control units feeding a 20 pct lime slurry.

Copper sulphate, potassium amyl xanthate, and hydrated lime are handled from railroad cars to

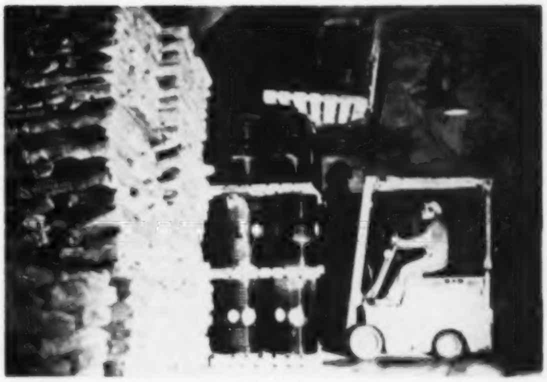
Mill tailing travels 3.5 miles down Eagle River Canyon to this distribution line at the pond. Final tailing carries about 70 pct pyrite and is unsuitable for mine fill.

storage with a 1-ton Clark electric fork truck. These reagents are mixed to proper concentration, then pumped into storage tanks in the mill.

The feeding of a 20 pct solution of copper sulphate is automatically controlled and recorded through a Fischer & Porter Flowrator control unit and 10 pct solution of sodium cyanide is also fed through Flowrators. Xanthate and pine oil are stage added throughout the flotation sections with Clarkson feeders. Steps toward instrumentation in reagent feeding have resulted in saving of reagents, more rigid control and better flotation operation.

Water from the zinc concentrate thickener tanks and from the zinc middling thickener tank is reused partly in the flotation section spray system and partly in the grinding section.

All sampling is automatic and samples are collected and sent for assay at the end of each shift.



Fork truck is stacking xanthate in the underground reagent storage and mixing room. Pelletized lime in left foreground.

Plant and Service Dept.

by Harold Stienmier

THE plant dept. is responsible for the distribution of power for the operation, for compressed air for mine and mill, water for use in the mine and for domestic use in mine, mill, and the town of Gilman, fire protection for the operation, shop and repair facilities for the mine and mill, sewage disposal, and general construction and maintenance of buildings and housing.

Electric power is supplied by the Public Service Co. of Colorado and is transmitted to their Gilman substation at 100,000 v. It is delivered to the company at 13,000 v and is transmitted to the underground transformer stations through special submarine type cables. General Electric transformers in use underground are pyranol filled. Power to the mill substation is carried over surface transmission lines. Distribution underground and in the mill is at 440 v in either rigid conduit or by specially insulated rubber covered cable.

One Chicago Pneumatic and three Ingersoll-Rand air compressors are located in Belden at the bottom of the Eagle River Canyon. Two Ingersoll-Rand units are equipped for either electric motor or Pelton wheel drive. The majority of the power for the compressors is purchased. A small amount of power is generated by a Pelton wheel driven generator set during the summer months and some compressed air is produced by water power during the period of maximum run-off.

A general mine repair shop, machine shop, and an electrical service shop are located underground in the mill area. A shop for repair and servicing the haulage locomotives and their batteries is on the 16th level near the main hoisting station. Baldwin and Atlas haulage motors are used. Edison storage batteries are used on both types.

The cap lamp charging and repair station is also underground near the No. 1 shaft. The carpenter shop, plumbing shop, and a small electrical shop are in the surface warehouse building and provide facilities for maintenance and construction of plant buildings and housing.

Domestic water supply for the town of Gilman and for use in the mine is obtained from Rock Creek on Battle Mountain and from Fall Creek across the Eagle River Canyon. All water for domestic purposes is chlorinated.

The domestic water system also serves for fire protection, the water storage tanks having a capacity of 200,000 gal. Fire hydrants with hose houses are located throughout the town and plant, and a volunteer fire department is trained in the operation of a modern, pump-equipped fire truck. All of the major buildings are protected by dry pipe automatic sprinkler systems. Hand fire extinguishers are distributed throughout the entire operation and are mounted on all mobile equipment.

The sewage disposal system serving the town is a multiple tank septic system located well down in the canyon. The effluent is chlorinated and sent to the tailings pond.

A safety inspector maintains first aid stations throughout the mine, mill and plant. Modern mine rescue equipment, dust and gas sampling apparatus are centrally located in the mine office building. A special room is provided for the first aid and mine rescue classes which are conducted at regular intervals. The safety inspector makes regular inspections of the entire operation, conducts all first aid and mine rescue classes, checks mine ventilation, obtains and analyzes dust and gas samples.

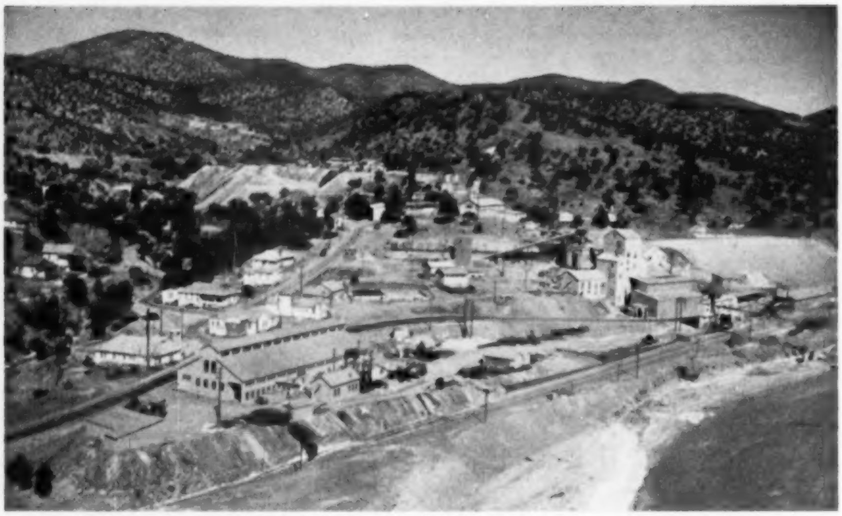
A small, well-equipped, modern hospital operated by the company provides medical as well as hospital service for Gilman and the surrounding area. A modern ambulance is garaged in the fire station convenient to the No. 1 shaft.

Recreation facilities include a club house in Gilman and a large recreation area along Cross Creek at the foot of Battle Mountain. Available in the club house are bowling alleys, dance hall, club rooms, library, and dining hall. In the recreation area are lighted children's playgrounds, basketball and tennis courts, and a softball diamond. A hardball diamond is also located in this area.

The town of Gilman has 100 dwelling units of which 18 are apartments. Thirty-eight of the units are new, single family dwellings constructed in the last 3 years.

New Jersey Zinc

The Hanover Mine



HANOVER mine in the Central Mining District of southwestern New Mexico has been operated almost continuously since 1903 by the Empire Zinc Div., and has produced over 2½ million tons of crude ore varying in grade from 7 pct to 17.5 pct zinc and carrying a small percentage of lead.

The history of this mine is not unlike many other zinc mines—starting with the production of high grade, direct shipping carbonate ores, then later the zinc sulphide ores low in lead were developed, produced, and milled in a magnetic separation plant. Flotation was introduced in 1926 and by 1929, all ores were handled by this method of concentration, permitting the mining of lower grade ores and ores of mixed sulphide content.

This operation, however, does differ from many others today in that it operates a custom mill handling ores from neighboring mines and other mines in the state as well as ore from the Hanover mine. Ores milled vary in zinc content from about 5 to 14 pct and in lead content from 0.1 to 3.5 pct.

Production at the Hanover mine varies with the amount of custom ore being handled. Mill capacity is about 800 tons per day, of which the Hanover mine may supply from 25 to 50 pct.

When operating on a normal basis, Hanover employs between 125 and 175 persons including staff, and produces between 2500 and 3500 tons of zinc concentrates per month.

Geology

by J. S. Horton

THE zinc orebodies are pyrometasomatic replacement deposits in limestone. The major intrusive, a granodiorite stock, is of primary importance, first, providing the favorable structure for ore deposition, and second, the emanations carrying the ore minerals. The majority of the orebodies are confined to the upper member of the Mississippian which is locally referred to as the *crinoidal* limestone. Less important orebodies are found in the basal Mississippian and scattered throughout the Pennsylvanian limestones.

Sedimentary rocks exposed in the area range in age from the Cambrian through the Cretaceous and include limestones, dolomites, shales and sandstones. The crinoidal limestone is a coarse, recrystallized, white, pure limestone having a normal thickness of 110 ft and appears to have been the best ore host rock. (See p. 1230 for section.)

Igneous rocks, in addition to the granodiorite stock, are granodiorite dikes, numerous diorite sills, and various types of post-ore dikes.

Deformation due to lateral pressure by the granodiorite stock has resulted in folding of the Carboniferous limestones creating a tight overturned syncline adjacent to the intrusive with open upright asymmetrical anticline beyond. Thrust faulting in connection with lateral forces is also in evidence; and due to folding, thrusting and plastic flowage, the crinoidal limestone varies in thickness in this deformed area from 25 to 300 ft.

Numerous steeply dipping normal faults radiate from the intrusive to the south and southwest. Generally the displacement is quite small, amounting to only 20 or 30 ft. Several of these small faults have provided channelways for access of the granodiorite dikes and ore solutions.

Ore deposits have two habits of occurrence. Adjacent to the periphery of the intrusive on the silicate-limestone contact is a blanket of ore approximately 40 ft wide occurring discontinuously along the southwestern and southern borders of the intrusive for a distance of 7000 ft. The second type is the vertical tabular extended replacement orebodies adjacent to the granodiorite dikes. These ore zones usually persist through the complete vertical extent of the crinoidal limestone, have an average width of 20 ft, and a discontinuous strike length exceeding 1500 ft. Locally a zone of garnet is found between the orebody and the dike in the latter type deposit.

The ore in both habits of occurrence is usually intimately associated with hedenbergite although it also occurs in the garnet and limestone. Contacts of

the ore and limestone are relatively sharp while the ore-garnet contact is somewhat graditional.

The principal ore mineral is sphalerite and it is associated with minor amounts of galena, chalcopyrite, and rhodochrosite. Zoning of these minerals is quite apparent in several of the stopes. A narrow band of galena envelops the outer perimeter of the zinc sulphide orebodies. Frequently a narrow band of rhodochrosite occurs between the galena and the limestone giving a zonal sequence of sphalerite, galena, rhodochrosite, and raw limestone.

Silicate contact minerals are garnet (andradite), epidote, hedenbergite, and ilvaite; garnet being the earliest silicate and ilvaite the latest. Magnetite and hematite were introduced during the late silicate stage. The sulphide mineralization followed the silicate stage, penetrating the silicates along fractures and other openings to deposit at the silicate-limestone contact as well as in the blades of the hedenbergite.

Left to right: W. T. Pettijohn, Superintendent; C. C. Snell, Assistant Superintendent; J. S. Babcock, Mine Chief; and J. S. Horton, Geologist.

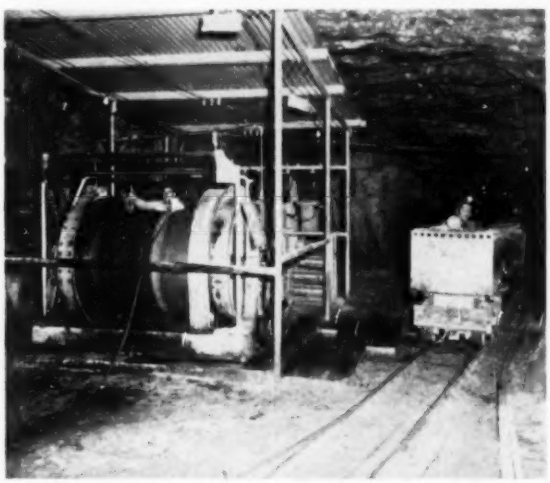
Mining Operations

by J. S. Babcock

MINING operations at Hanover are carried on underground and on the surface where some of the larger orebodies outcrop. Open cut ore varying in grade from 4 to 7 pct zinc accounts for about 33 pct of the tonnage produced. Underground grade varies from 7 to 10 pct zinc.

Underground operations are on a two-shift basis employing about 62 men, while the open cut operates one shift and employs about 8 men. An over-all production rate of 8 tons per manshift is normally obtained.

Primary drilling in the open cut is done with wagon drills using both down and toe holes on benches 15 to 25 ft high. Secondary breaking of oversized ore boulders is accomplished by drilling with light jackhammers and then blasting. Broken ore and waste are removed in a ratio of about 1 to 1, employing a ½-yd Michigan diesel shovel, a D-7 bulldozer, and two 10-ton White dump trucks.



Hoist and haulage at the Theta incline shaft, underground at Hanover. The two 15° sub incline shafts extend from the bottom of the 220-ft vertical main shaft, following the ore horizon.

Main entry to the underground mine is through a three compartment 220-ft vertical shaft, which is used for service, and ore hoisting (car and cage). From the bottom level two 15° sub incline shafts, about 900 ft long, are in the favorable stratigraphic ore horizon.

Extraction raises and drifts are run in ore whenever possible, with levels spaced between 50 and 100 ft vertically. The 7x7-ft drift headings are normally driven by two-man contract crews using Ingersoll-Rand DA-35 or DB-30 drifters on two-machine jumbos. A complete cycle, including drilling, blasting, mucking, and laying track and pipe, is usually obtained each shift, with advance averaging 4.5 ft per round.

Raise crews using I-R R-48 stopers normally drive 48° incline raises without timber. Excepting for certain types of dikes and fault zones, ground conditions are good and little timbering is required.

Early day mining employed shrinkage stoping with stopes about 20 ft wide, 100 ft high, and 100 ft long. The mine grade cut-off was around 16 pct zinc, and ore containing more than 0.1 pct lead was not amenable to then existing milling and metallurgical practices. These factors combined with the irregular outline of the orebodies left a considerable tonnage in the stope walls, which today is ore grade. Mining the remaining portions of these orebodies accounts for a major part of today's production.

An open stope system of mining is used both for new orebodies and for cleaning old stopes. New orebodies are developed by driving inclined raises to the upper limit of the ore and these raises connect to the level above. Slabbing and benching with stopers, jackhammers, and recently the I-R JR-38 jackleg, develop the ore to its horizontal limits. Benching then develops the stope to the bottom of the orebody. Cleaning the old stopes follows a similar procedure except that access to the back of the ore is obtained by driving prospect trails in ore along the stope sides. Sullivan and I-R 15 and 7½

hp electric scraper hoists are used where the broken ore will not flow by gravity to the draw points. Broken ore is loaded both from chutes, and from draw points using Eimco 12-B or GD-9 shovel loaders. Trains of ten 15.5-cu ft end dump cars are pulled to the shaft with 1½-ton Mancha storage battery locomotives.

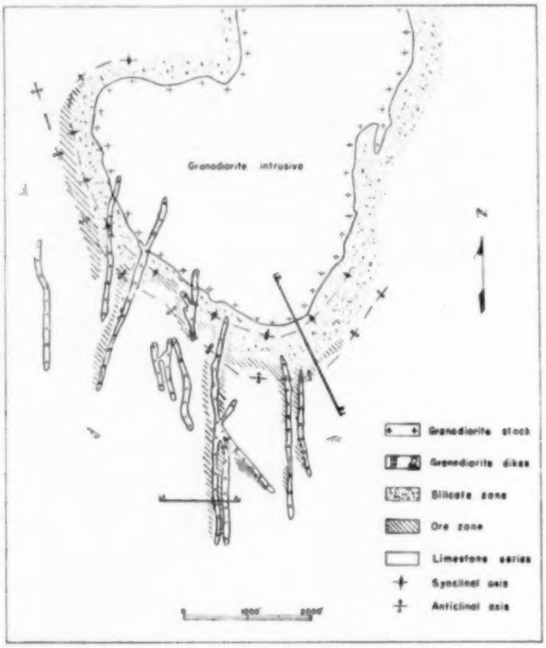
Multi-use I-R steel jackbits are normally used throughout the mine, though tungsten carbide bits yielding a footage of 240 to 350 ft have proved economical in hard ground.

The 50-gpm flow of mine water is pumped to surface storage tanks, and utilized by the mine and mill. Four compressors service the plant with a total capacity of 2370 cfpm.

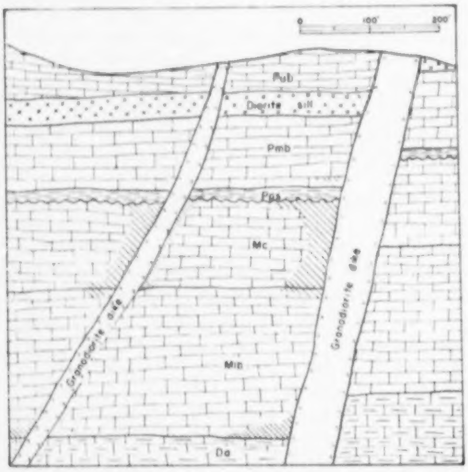
Natural ventilation is good throughout the mine, due to the numerous old stopes which have been mined to the surface.

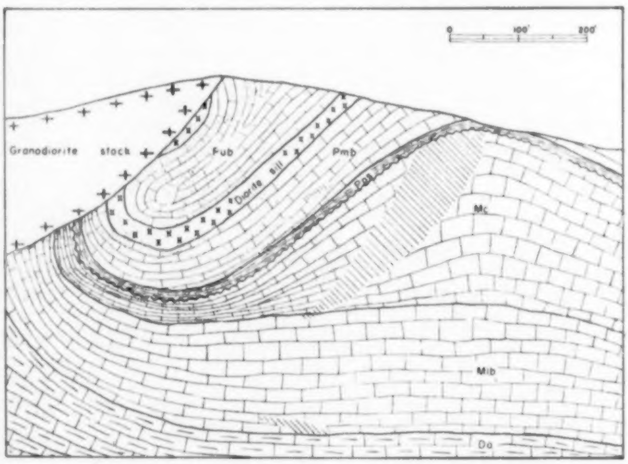
Hanover Geology

CRETACEOUS	Colorado formation	(Kc)	915 ft
PERMIAN	Abo	(Ca)	200
PENNSYLVANIAN			
	Syrena limestone	(Cs)	380
	Upper blue limestone	(Pub)	308
	Middle blue limestone	(Pmb)	90
	Parting shale	(Pps)	18
MISSISSIPPIAN			
	Crinoidal limestone	(Mc)	110
	Lower blue limestone	(Mlb)	193
DEVONIAN			
	Augen bed	(Da)	100
	Percha shale	(Dp)	260
SILURIAN			
	Fusselman	(Sf)	40
ORDOVICIAN			
	Montoya limestone	(Om)	300
	El Paso limestone	(Oep)	350
CAMBRIAN			
	Bliss sandstone	(C-b)	150



RIGHT: Diagram shows relation of ore and silicate zones to granodiorite intrusive. BELOW: Sections show, (left) type of orebody associated with granodiorite dikes, and (right) relation of ore and silicate zones to intrusive.





Milling and Service

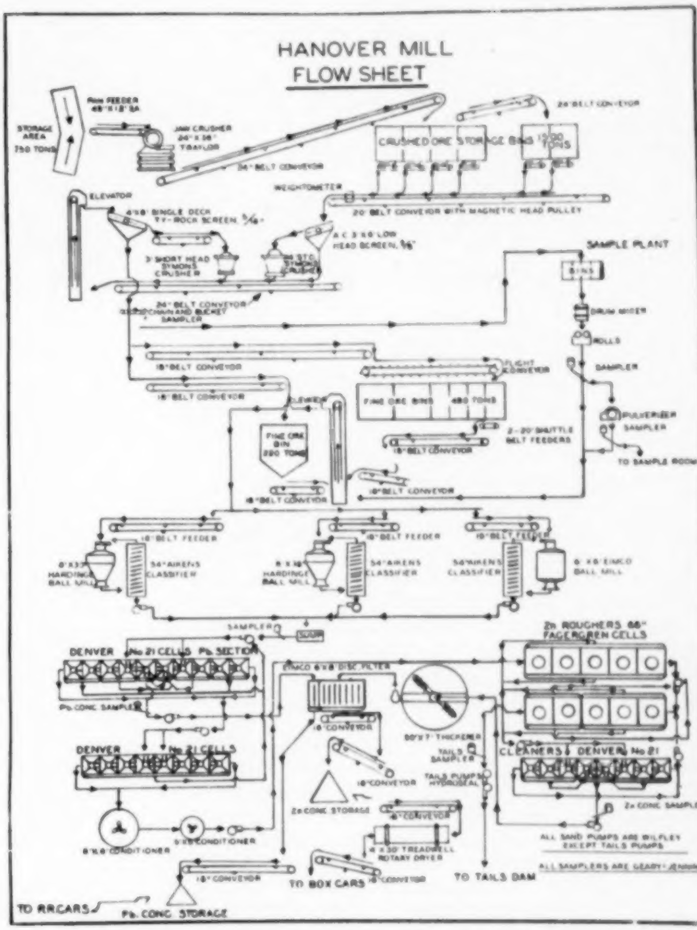
by C. C. Snell

THE mill, designed to treat custom ores, presents many interesting features not encountered in a plant treating ore from a single source. Normally about 50 pct of the ore treated is purchased from several different mines, and consequently this ore involves separate handling, storage, sampling, and milling. In order to facilitate the handling and storage and reduce the possibility of getting the ores mixed, certain bins are designated for each ore that is normally treated.

All ores are sampled after being crushed to −5/16 in. It is by these samples that the monthly analysis of the feed to the mill is determined, and settlements are made on purchased ore. A great deal of care was taken in designing an automatic sample plant that would eliminate the element of human error. The sample, 1/200th of the original feed, is cut by a chain and bucket sampler. It is then stored in

bins, and later run through the sampling plant. The sample is there reduced to 1/50th of the original sample or 1/10,000th of the feed weight. The final sample from the sampling plant is hand-mixed and split, and then pulverized for laboratory use.

Each of the ores is usually treated separately. Because of a wide variation in grade and mineral grain size, variations in reagents and in grind are necessary to obtain maximum recoveries. Separate milling also affords better indication of metallurgical efficiencies accomplished on each ore, though there is some blending in the circuit when ores are changed.



Primary Crushing and Storage

All ore is delivered to the primary crushing plant by truck. One outstanding feature is that instead of conventional storage bins ahead of the crusher, there are two concreted storage areas, separated by a pan feeder, into which the trucks dump the ore. There is also a hopper above the pan feeder into which the trucks can dump directly. This arrangement is very flexible, making it possible to receive three different ores at the same time.

Ore is transferred from the storage areas to the pan feeder by means of 42-in. Pacific type scrapers, pulled by 20 hp 3-drum Ingersoll-Rand hoists. The ore is crushed $-3\frac{1}{2}$ in. by means of a 24x36-in. Traylor jaw crusher, and is then delivered by belt conveyors and distributor to six crushed ore storage bins which have a total capacity of 1500 tons. Dust control is obtained with a type N Rotoclone.

Secondary Crushing

The ore is delivered to the secondary crushing section by means of a belt conveyor, equipped with a Merrick, type S, weightometer. Symons cone crushers reduce the ore to $-5/16$ in. It is then sampled and conveyed to storage bins, which have 700 tons total capacity.

Dust control is obtained by a type N Rotoclone, with hoods covering the crushers, screens, and all points of transfer.

Fine Grinding

As shown on the flow sheet, the fine grinding section consists of three ball mills (two Hardinge and one Eimco) each in closed circuit with a 54-in. Akins classifier. Due to the variation in character of ore treated, the tonnage varies a great deal. The maximum total capacity is approximately 35 tons per hr. Forged steel balls and Moly-chrome liners are used. A rationed charge of 75 pct 3-in. balls and 25 pct 2-in. balls is added to each mill each shift. The average ball consumption is approximately 1.5 lb per ton of ore. The classifier overflow density varies from 38 to 45 pct solids. The ores are ground to 15 to 20 pct +100, and 55 pct −200 mesh.

Flotation

Lead roughing and cleaning are performed in Denver No. 21 flotation machines. There is no conditioning time between the classifiers and the lead section. A mixture of 2/3 sodium xanthate and 1/3 Pentasol xanthate is used as a collector in the lead section. Carbinol is used for the frother. Cyanide and zinc sulphate are used as zinc depressants in the cleaners. The lead separation is made at 8.0 to 8.5 pH. No lime is usually required to maintain this alkalinity.

Zinc roughing is performed in 66-in. Fagergren flotation machines, and cleaning in Denver No. 21 machines. Copper sulphate, lime, and Aerofloat 238 are added to the conditioners between the lead and zinc sections. Pine oil and Aerofloat 238 are stage added through the zinc circuit. A pH of 9.6 to 10.8 is maintained in the feed to the zinc roughers. A pH of 11.0 is maintained in the cleaners. Automatic pH control in the feed to the zinc roughers is obtained by means of Beckman-Brown control equipment to regulate the lime feed rate. Wilfley laboratory concentrating tables are used as a visual aid to the operator in checking the tailing and zinc concentrates. All the products are automatically sampled by means of Geary-Jennings samplers.

Concentrate Handling

The concentrates are conveyed from the Eimco 8 disk filter to storage floors. The zinc concentrates, as required, are then scraped into another conveyor system, which feeds the dryer, and are in turn fed into boxcars and shipped to one of the company's

smelters. The lead concentrates are scraped from the storage floor directly into hopper cars and shipped to an outside smelter.

Tailing is pumped to the storage dam 3000 ft away. The berm of the dam is built up with a bulldozer and the tailing then distributed inside the berm. Water is reclaimed from the dam for re-use in the mill.

Electric power is purchased from the Community Public Service Co., entering the plant substation at 13,000 v, and 1500 kva transformers, owned by the power company, reduce the voltage to 480 for distribution to mill, mine, and shops.

An up-to-date machine shop, warehouse and compressor plant are located centrally in one building. The shop is well equipped to handle any repair or construction job normally arising in an operation of this size.

A modern assay laboratory conveniently located between the office and the mill is maintained where mill samples are analyzed daily, thus affording good metallurgical control of milling operations.

Canon City

Robert Davis, Superintendent of the Canon City, Colo., plant of the Empire Zinc Div.

THE Canon City plant of The New Jersey Zinc Co. was built in 1902 to treat by magnetic separation the large tonnages of zinc-iron middlings which had accumulated from the production of lead concentrates at Leadville, Colo. In 1920 an American process oxide plant was added.

With the exhaustion of the middling accumulations and the introduction of selective flotation the usefulness of the magnetic separator plant ended, and the entire operation was suspended early in 1932.

Rising demand for zinc immediately prior to World War II caused the reactivation of the Canon City roasting and sintering facilities which have continued to operate on zinc flotation concentrates supplied by the Eagle mine at Gilman, Colo.

The plant includes two Ropp roasting kilns, one Dwight-Lloyd sintering machine, and a fume collector in which exhaust gases from the sintering operation are filtered for the recovery of metal values.

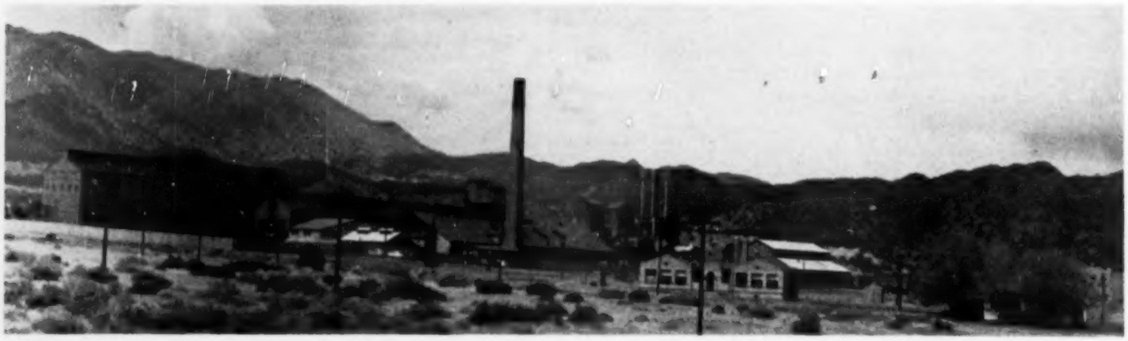
In practice, roasting and sintering overlap and may be considered as an integrated roast-sintering operation. The two Ropp single-hearth kilns, 14x175 ft, including a cooling hearth, are heated by natural gas. The gas is burned with radiant flame in simple open pipe burners which project through the kiln walls at 3-ft intervals. A relatively low roasting temperature is maintained and in its travel through the kiln the concentrate is roasted to a sulphur content of about 8 pct. The discharged roast is conveyed directly to the sintering plant.

In the sintering operation an addition of green concentrate replaces the carbon generally mixed in sintering bed charges. This green concentrate addition equals approximately one fourth of the weight fed at the roasters.

Sustained capacity of the combined operation is approximately 100 tons of green concentrate per day. The sintered product is shipped to the smelting plant at Depue, Ill.

The fume collector, designed by the American Wheelabrator & Equipment Corp., was installed in 1951. In operation the exhaust gas from the sintering machine is cleared of solids by filtering tubes of Orlon fabric. These filtering tubes are housed in four air-tight compartments, insulated for protection against condensation, and located on the pressure side of the sinter machine exhaust fan. Timed cycling controls operate dampers and tube shaking devices to keep the collector in continuous operation. The fume shaken from the filtering tubes is collected in steel hoppers to which the open ends of the tubes are attached. Periodically these hoppers are emptied through valves to a Hapman disk type conveyor by which the collected dust is delivered to a rotary muffle. The rotary muffle, externally heated by natural gas, is operated at low temperature to avoid fusion of the fume. Passage through the heated muffle acts to densify the product for shipment.

Metal values recovered by the collector include cadmium, lead, silver, gold, and zinc.



The Administration Building, Palmerton.

New Jersey Zinc

Palmerton

The Plants —

The Processes

FORMATION of The New Jersey Zinc Co. by the consolidation in 1897, put together the processes and know-how of the several companies for the smelting of zinc, iron, and manganese bearing ores on a much more efficient and economical basis. As a result, plans were prepared for a new smelting plant. A site along the Lehigh River, north of Lehigh Gap, Pa., was selected because it had good railroad facilities, was near the anthracite fields and at the same time not too far from the New Jersey mines; an ample supply of water was at hand, and space was available for a townsite and future plant expansion.

Construction of the new plant and development of a well-planned town was started in 1898. The town was named Palmerton for Stephen S. Palmer, president of the new company. A subsidiary, The New Jersey Zinc Co. (of Pa.), was established to carry on the operations of the new plant.

This plant, now called the West plant, had furnaces and equipment for producing zinc oxide, slab zinc, and spiegeleisen, as well as a steam and power plant and many shop facilities.

Confidence of the new company in the growth of markets for these products was well justified and the plant expanded rapidly. By 1910 the demand for zinc oxide exceeded the capacity of the oxide furnace div. and plans were made for expanding east of the town. In 1912 the American Process zinc oxide div. of the East plant was placed in operation.

Concurrent with development of the manufacturing operation, the company provided a potable water system, sewage disposal plant, light and telephone service for the town, built homes for members of the staff and workmen, and assisted in development of schools.

A hospital was built by the company in 1908. Expanded to 65 beds and completely modernized during the past year, its competent staff offers excellent surgical and medical facilities for the residents of the town and nearby communities.

The Neighborhood House was provided for promoting and assisting sociological activities in the community. This contains a gymnasium, game rooms, bowling alleys, meeting rooms for Boy Scouts, Girl Scouts, and local clubs, as well as office space for the community nurse, a free service provided by the company. A public library and a section of the public school's kindergarten also have their quarters in this building.

Throughout the years, the company has been deeply conscious of the important roles which research, engineering, and market development have played in its growth. It is logical, therefore, that today the company organization consists of three major departments based on these functions, manufacturing, engineering, and research. The managers of these departments report to the vice president and general manager.

Necessary for these operations are the purchasing agent and his staff reporting to the vice president and general manager, and the personnel and clerical depts., the heads of which report to the assistant general manager. He is also responsible for the operations of three subsidiaries, The Palmer Land Co., the Palmer Water Co., and the Palmerton Disposal Co. The Horse Head Inn, which is provided for the convenience of people who visit Palmerton in connection with company matters and as quarters for single staff people, and the Palmerton Hospital are administered by the assistant general manager.

The personnel dept., with a staff of 16, is responsible for employment, employment records, safety and health, first aid training, employee relations, training and communications, insurance and pensions, and wage and piece-rate matters.

P. T. Vanderwaart, Assistant to the Vice President.

L. F. Johnson, Assistant General Manager.

G. F. Halfacre, Manager of Manufacturing.

Research

by R. K. Waring

Research and Analytical Laboratory, Palmerton

ORGANIZED on a modest scale in 1907, the research dept. grew slowly over the next 10 years. In 1918, stimulated by war needs, it expanded rapidly to a total of 140 men. Growth continued and it now has 180 salaried people, with hourly rated employees fluctuating in number between 100 and 175, depending on the pilot plant work load.

Coincident with the rapid expansion, a modern, three-story research and analytical laboratory was built in 1919. Additional facilities have been added as the needs developed and at present the department occupies, wholly or in part, eight laboratory buildings. A number are grouped in a field station, adjacent to the Palmerton East plant, and are for crock-scale and pilot plant development work.

The department is under the direction of a manager and asst. manager of research. Under these men, are six divisions: chemical research, metallurgical research, minerals research, products application, chemical development, and metallurgical development. Each of these is in charge of a chief, who is assisted by one or more supervisors. Experienced and competent investigators, although under this supervision, have a great deal of latitude in carrying on their experimental assignments and bear a corresponding responsibility.

The purpose of the research dept. is to contribute to the activities of the company in three major fields: exploration and mining, manufacturing, and sale of products.

Exploration and Mining

This comprises four fields of research: geophysics, geochemistry, laboratory geological studies, and ore dressing.

In geophysics the objective is to intelligently and effectively utilize geophysical methods of prospecting for orebodies. The research team investigates the use and interpretation of established methods, modifies and improves apparatus, and devises new methods and variations of old methods. This entails laboratory modeling studies to aid in interpretation of field results, field experimentation with methods and equipment, cooperation with exploration geologists in use of the methods, training of geologists in the use of geophysics and general assistance in the interpretation of results and integration of geophysics into the company's exploration program.

Effects of subsurface ore upon the chemical composition of the overlying rock, soil, and vegetation are utilized in geochemical prospecting. A generally known procedure is to search for anomalous distribution of trace elements in the soil. The contribution of the research dept. here has been mainly in the development and testing of methods of chemical analysis and in the utilization of special laboratory techniques, such as spectrographic and polarographic analysis. It is recognized that much needs to be known about the fundamentals of geochemistry to intelligently interpret the results of geochemical prospecting. Research in this direction is in progress.

The research dept. maintains complete facilities for the laboratory study of rocks and minerals. These include the preparation of thin sections and polished sections, microscopic facilities, and equipment and procedures for mineral separations, analysis and identification. Effective use is made of spectrographic analysis and X-ray diffraction. Cooperative research with the company's geologists is conducted on problems of ore genesis, such as rock alteration, where laboratory research is needed to augment field investigations. This program has proved to be effective in the difficult fields of modern day ore exploration and evaluation.

Ore dressing is an essential step between the mining of ore and its smelting, and the research dept. is well equipped to investigate milling problems. Laboratory equipment for gravity, magnetic, and flotation separations is used intensively. Chemical problems fundamental to flotation are investigated, and mineralogical studies of ores are made. Processes

Left: R. K. Waring, Assistant Manager of Research. Right: D. L. Gamble, Manager of Research.

devised in the laboratory are further developed and tested in the pilot plant equipped so that continuous tests can be made yielding metallurgical results indicative of what may be expected in commercial plants. Research metallurgists maintain close contact with mill metallurgists to effectively coordinate research efforts with plant experience and practice, and substantial changes in milling practice have resulted. Engineers in the research dept. are actively studying problems of instrumentation and automatic control as applied to milling.

Manufacturing

Improvement of metallurgical and chemical processes and development of new processes have been important activities of the department for many years. The approach to a major project usually involves study of fundamental scientific problems, such as determination of chemical equilibria and reaction rates, laboratory trial of proposed processes, pilot plant operation, engineering studies, and economic estimates, the last two of which are carried out in close cooperation with the engineering dept. Staff and facilities are available to prosecute work along all of these lines. Several projects are described in the following paragraphs:

Fluid bed roasting of sulphide ores has been studied extensively on a laboratory scale and on pilot plant scale. An experimental fluid bed roaster of commercial capacity is now in operation. The over-all investigation has included, in addition to the study of the roasting reaction itself, extensive mechanical design studies, selection and trial of materials of construction, and development of methods of charge preparation. When zinc sulphide ores are processed in this type of roaster, they need no further sintering before going to the smelting operation.

The electrothermic Sterling process was the result of extensive experimentation with the smelting of

Flotation testing in this pilot plant is one of the many services performed by the research dept. in the field of mining activity.

This Lectromelt arc furnace is used for small scale smelting studies.

ores from the Sterling mine; then was further developed in size and flexibility so as to treat other types of zinc ores. A small 500-kw furnace is used to ascertain optimum conditions for treating a wide range of ores and zinc-bearing materials with especial attention to the behavior of other metal values in the various charges. In the larger 6000-kw furnace operating techniques have been perfected, refractories tested, and data as to efficiencies, costs and capacities determined.

Another zinc smelting process, the vertical retort process, was brought to successful commercial operation over 20 years ago, but further improvements in design, efficiency, and capacity are still being made. Especially notable are the new splash condensers for zinc vapor which have substantially increased condensation efficiency. Considerable attention has been given to improving the charge briquetting and coking practice, and possible uses for the spent briquets have been studied.

The New Jersey Zinc Co. is much interested in titanium—in its ores, its metallurgy, its compounds, and in the metal itself. Through its participation in the Quebec Iron & Titanium Co., it is interested in the utilization of a slag rich in titanium. The production of titanium dioxide pigment from the slag has been investigated intensively. The chemistry of titanium has been studied extensively in a search for methods of making pure titanium metal. Many processes have been considered with particular emphasis on an electrochemical process.

Not only other metals than zinc but other forms of these metals have interested this group. Powdered metals which can be pressed into useful forms have been the object of much experimentation, resulting in methods of making promising powdered alloys of zinc, copper, and nickel to supplement the commercial brass, bronze, zinc, and copper powders. High quality iron powder has many desirable characteristics, and a method is under development for making it directly from ore.

The most effective way to recover the small amounts of precious metals present in many zinc ores has presented many interesting problems. The obtaining of these values during milling, roasting, sintering, briquetting and coking, smelting or from the final zinc metal has possibilities which may vary from ore to ore. These, as well as separate metal recovery steps, have been the object of a great deal of investigation.

Although the making of zinc oxide was one of the first processes undertaken by this company, improvements are still being developed. Extensive studies of the surface chemistry of pigments and means of modifying their surface characteristics have resulted in the Protox series of zinc oxide pigments now widely used in rubber compounding.

Sales

Research and development are required to best apply the products to the needs of consuming industries. To do this adequately, there has been assembled typical fabricating equipment such as rubber and paint mills, die casting machines, metal powder press, etc. An authoritative knowledge has been acquired of commercial operations in virtually every field of zinc product use. Extensive testing, X-ray, and evaluation equipment, much of it, such as the accelerated weathering test for paints, developed here, is provided to permit evaluating the company's products and the end products of the manufacturer.

Important functions are the development of new products such as alloys, coated pigments, luminescent pigments, etc., and the determination of the feasibility of entering new fields of primary product manufacture. In these areas the work is not restricted to zinc.

The best known activities of the products group have been their studies of end products and their proper use. Nearly 400 papers have been published of investigations in the fields of plating, corrosion, die casting, paint formulation and service behavior, rubber technology, and many others. The work has been broad. Many basic studies have been made such as on the deformation habits in zinc and titanium single crystals, the relation of particle size and distribution to the effects of pigments on paint and rubber properties, the mechanism of the corrosion of steel under paint films in sea water, the stress-corrosion cracking of wrought brass, etc.

In the area of more direct practical application, there have been studies such as on the principles behind good die casting die design, the factors controlling quality in electrodeposits, the dispersion of pigments in rubber, water leakage as the cause of paint blistering, and creep behavior of die castings.

Engineering

by J. R. Connelly

Engineering and purchasing offices and certain products research activities are located in this building at Palmerton.

IT has long been the policy of the company to provide its own engineering service. Prior to 1912, the department was located in the parent company's office in New York. At that time, the engineering activities for the manufacturing dept. were established at Palmerton in order to expedite the design and construction of new and rapidly expanding production facilities. During the period from 1912 to 1918 there were completed a lithopone plant, a Mathiessen and Hegeler roast kiln, a sulphuric acid plant, a zinc rolling mill, and major additions to the slab zinc and zinc oxide smelting plants.

Later, the activities of the engineering dept. were broadened to include consultation and design work for the research and mining depts. and for licensed plant operations. The department has charge of the construction of all new installations and improvements. It collaborates with other departments on heavy maintenance work where the use of its construction equipment and manpower is advantageous. Other responsibilities include the maintenance of capital value records for tax and insurance purposes, and keeping abreast of local, state and federal codes and regulations.

The engineering dept. is headed by the manager of engineering, who reports to the vice president and general manager of The New Jersey Zinc Co. (of Pa.). In addition to the manager there is a chief engineer, an asst. chief engineer, with a staff of about 40, including mechanical, civil, and electrical engineers, designers and draftsmen. The construction div. of the engineering dept. consists of a permanent field staff of construction engineers, surveyors, and foremen, amounting to 15 men. The field force of skilled workmen and laborers fluctuates but averages about 130. Craft workers, such as masons, electricians, and instrument technicians are obtained from the service and maintenance dept.

An outstanding job undertaken and completed since World War II was the modernization of the smelting facilities with increased capacity for the

Left: F. C. Peters is Manager of Engineering. Right: J. R. Connelly, Chief Engineer.

treatment of sulphide ore. The first stage was the design and construction of a second roaster, with a new acid plant, and sintering facilities, placed in operation in 1949. A peak capacity for 300 tons of green ore per operating day has been attained on this roaster.

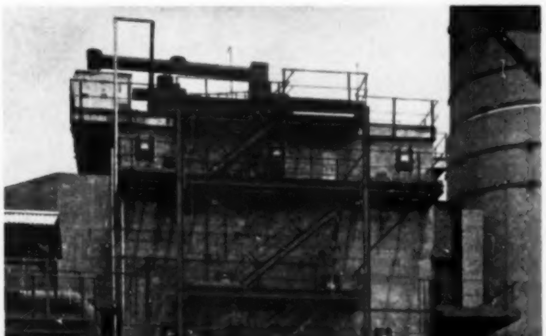
The roaster is basically a Trail suspension type, modified and enlarged for more capacity. The two ore drying hearths are at the bottom of the roaster instead of at the top, and because of this change the central shaft does not pass through the combustion zone. The roasted ore, after passing through water cooled screw conveyors, is delivered to bins by Fuller-Kinyon pumps.

The sintering machine, American Ore Reclamation type, with a 6x76½-ft windbox, can produce sinter of the desired quality at the rate of 600 tons per 24 hr. The sintered product, after passing through a Kennedy Van Saun slugger roll, is screened producing a coarse material for the sinter machine hearth layer and an undersize as feed for a 6x12-ft Hardinge rod mill. The rod mill product is delivered by railroad cars to the smelter operations.

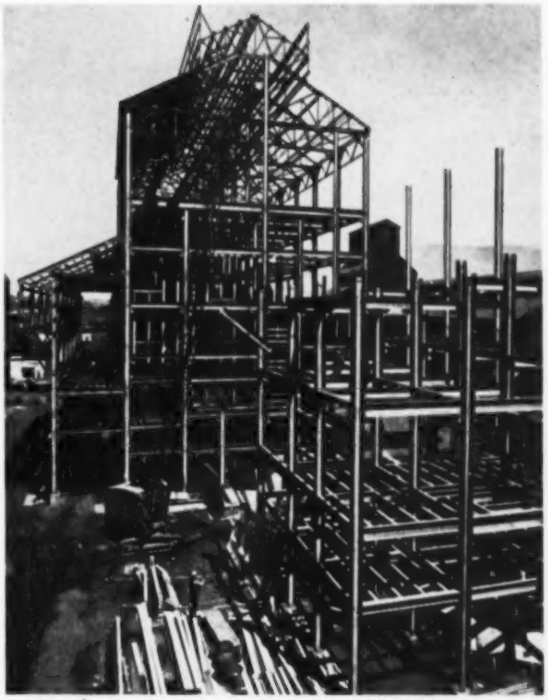
Fume containing considerable amounts of lead, zinc, cadmium, and at times small quantities of gold and silver, is recovered by passing the sinter machine gases through a conditioner and an electrostatic precipitator.

The electrostatic precipitator was supplied by the Research Corp. The unit is approximately 63 ft high, 50 ft wide and 37 ft long with a reinforced concrete framework. Walls of the precipitator are of vitreous hollow tile, filled with lumnite cement applied by a cement gun, with reinforcing bars inserted in the hollow tile. This entire structure was constructed during the winter months without difficulty. Tarpaulins and steam heaters were used to maintain a uniform temperature during construction.

The acid unit is a Monsanto design vanadium catalyst contact process plant having a nominal capacity for 240 tons H_2SO_4 as 66° Bé acid. The plant is arranged to supply a demand for higher



Engineering Dept. responsibility for all construction includes projects such as this electrostatic precipitator shown during the later stages of installation.



This photograph shows steel being erected for the vertical retort building by the construction div.

grades of acid. Loading facilities have been provided for the shipment of acid in tank trucks or tank cars.

Coincident with the roasting and acid expansion, preliminary consideration was given to improvements in the vertical retort continuous smelting operation. This led to an authorization in 1948 for the construction of a new battery of larger retorts. The capacity of the furnaces was increased over the previous installations and numerous improvements were developed with the close cooperation of the manufacturing and research depts. These included greater heat recuperation, autogenous coking, splash condensers and finer grinding of bituminous coal. The plant was put into successful operation in October 1950.

Considerable work has been done during recent years on improvements to the zinc oxide plants. A Waelz kiln operation, consisting of three kilns—one 10x140 ft, and two 11¼x160 ft—was installed during the period 1929 to 1938. This operation produces a concentrated zinc oxide from low grade zinc materials and makes possible increased burdens on the commercial zinc oxide furnaces. A Dwight-Lloyd sinter plant was erected in connection with the Waelz kilns to agglomerate the Waelz oxide and to make it more suitable for use on the oxide furnaces.

The Palmerton plant for making French Process zinc oxide has been improved and expanded since 1945. The furnace design incorporates the principles of the company's processes for refining zinc. A Wheelabrator automatic bag system has been successfully applied to the collection of French oxide.

Much has been accomplished in the handling of materials and products by means of pneumatic conveyors, Fuller-Kinyon pumps, lift trucks, etc. This is a continuing study, and study is also being given to the mechanical casting and automatic stacking of slab metal.

Manufacturing

WEST PLANT—Left to right: areas for slab zinc, spiegel, power and shops, and zinc oxide.

FOR the operation and maintenance of the Palmerton plants, the manager of manufacturing has a staff which includes a superintendent, and assistant superintendent at each plant, and a department chief in charge of each operating or service department.

Since its construction, the major products of the West plant have been American Process zinc oxide, slab zinc, and spiegel-iron. But manufacturing operations have become more complex with the changing requirements of the trade. A customer may now select from 17 brands of American Process zinc oxide, all made directly from ore. Slab zinc is currently produced in the following grades: Horse Head Special, Horse Head, brass special, and common metal. Chemically pure metal, analyzing to better than 99.999 pct Zn is produced for use in research and for customers requiring exceptionally pure zinc. Zamak, a zinc base die casting alloy, is produced by adding small amounts of grain refining elements (aluminum, magnesium, and copper) to Horse Head Special zinc. Zinc is also cast in special shapes for electrogalvanizing, cathodic protection, and other uses. Zinc dust is made in two grades, one for paint and one for the chemical industry. Four grades of spiegel range from 16 to 25 pct manganese.

At the East plant, originally constructed in 1911 to expand the American Process zinc oxide capacity, equipment has since been added to produce lithopone, sulphuric acid, leaded zinc oxide, zinc sulphide, luminescent pigments, metal powders, French Process zinc oxide (14 brands), and rolled zinc. Changes concentrated the manufacture of American Process oxide at the West plant on modern traveling grate facilities, and of lithopone at the Depue, Ill., plant. The East plant now processes by fire concentration (Waelz process), roasting, and sintering nearly a half million tons a year of zinc concentrates and other zinc materials destined for final smelting to finished products, mostly at the West plant.

In order to meet the changing trade requirements for zinc products, older tools, equipment and methods have been replaced with more modern ones through the efforts of the research, engineering, and manufacturing staffs.

Efficient traveling grate furnaces have made the Wetherill grate obsolete for production of American Process zinc oxide, the vertical retort process has supplanted the labor consuming, inefficient horizontal retort furnaces for producing slab zinc, modern autogenous roasters have replaced the M&H kilns, and the old Grillo-Schroeder sulphuric acid systems have long since given way to autogenous converter-heat interchanger units. In addition to these major metallurgical improvements, many devices lessen manual labor and improve working conditions.

EAST PLANT—Left to right: boiler house; roasting, sintering, acid plants, and research station; luminescent pigment, zinc sulphide buildings; buildings for oxides and metal powder; and the rolling mill in the right foreground.

J. A. Marvin, Assistant Superintendent, West Plant.

E. J. Flynn, Superintendent at Palmerton.

W. C. Seabright, Assistant Superintendent, East Plant.

Acid Dept.

by J. N. Ord

Mechanical handling speeds ore from stockpile to roasters.

THE acid dept., in the East plant, comprises three closely integrated operations—roasting, sintering and sulphuric acid. In addition, there are two pigment operations associated by reason of location and sulphuric acid requirements—luminescent pigments and zinc sulphide.

Incoming zinc concentrates ranging from 46 to 62 pct Zn, 29 to 33 pct S, and 2 to 15 pct Fe are unloaded from cars by railroad crane or payloader onto paved surfaces, box cars being unloaded direct to process when possible. A system of conveyors, feeders and storage bins with an oil-fired Hardinge rotary dryer which can be by-passed or used as required is arranged so that a separate ore mix can be fed to each of two roasters, making possible the simultaneous treatment of ores suitable for oxide or slab zinc production.

No. 1 roaster, started in January 1940, is a 19-ft high, 23-ft diam, conventional Trail suspension roaster design with a nominal capacity of 125 tons per day. Wet ore with moisture as high as 11 pct can be fed directly onto the open hearth atop the roaster, being rabbled to the center drop holes where it falls to the drying hearth on which it is rabbled in the opposite direction to a discharge opening in the roaster wall. Complete drying is effected by circulating a portion of the roaster gas over this latter hearth. Dried ore, after passing through a scalping screen, is ground in two parallel Hardinge air-swept ball mills, reducing the particle size to 98 to 99 pct −200 mesh and 93 to 95 pct −325 mesh. Milled ore is blown into the top of the combustion chamber, just under the drying hearth, with a mixture of drying hearth gas and air, some of which is cooling air from the central shaft and dust-laden air from a number of ventilation hoods. Complete dryness, fine grind and sulphur content, not less than 29 pct, are important in maintaining autogenous roasting with combustion chamber temperatures about 1000°C. Cooled gas is recirculated to the burner if hearth temperature becomes excessive.

Approximately 90 pct of the sulphide sulphur is eliminated in suspension with further removal taking place on two hearths below the combustion chamber. Roasted ore leaves the bottom hearth containing about 1 pct total sulphur (less than 0.5 pct sulphide sulphur) and is conveyed through water-cooled stainless steel screw conveyors to a Fuller-Kinyon pneumatic conveying system for delivery to the sinter plant or intermediate storage bins.

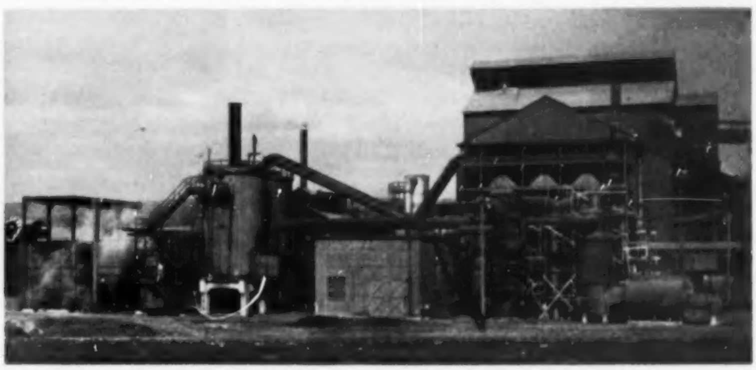
Gas, containing 9 to 10 pct SO_2 and 30 pct of the input ore as entrained dust, leaves the furnace through a breeching at the bottom hearth level and enters a system of atmospheric coolers, cyclones and a four-unit Cottrell with the units in series-parallel arrangement. A hot fan immediately ahead of the Cottrells provides suction for the system. Gas at 200°C with 0.2 grains per cu ft dust load is delivered to the No. 1 acid plant. Collected dust is conveyed back to the chamber hearth where it serves to reduce the temperature and minimize stickiness.

No. 2 roaster, started in May 1949, employs the same principles but nominal capacity was increased to 250 tons per day by increasing the height of the combustion chamber to 32 ft, retaining same diam, adding a second burner, relocating the dryer hearths at the bottom and terminating the central shaft just above the combustion chamber hearth. There are two Hardinge wind-swept ball mill systems each serving separate burner systems via Merrick constant weight feeders. The burners are diametrically opposed at the top of the combustion chamber. The roasted ore leaves the furnace through two opposite ports and passes through two parallel sets of water-cooled screw conveyors to the Fuller-Kinyon system.

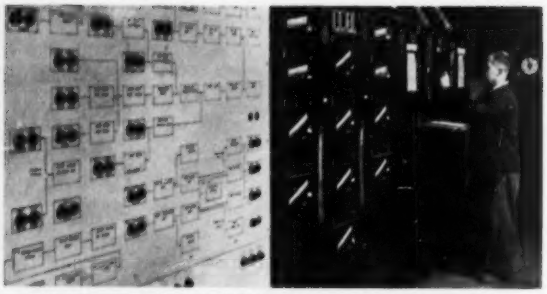
There are two gas outlet breechings, each leading to a 3-drum, single pass, 700-psi waste heat boiler with superheater at the low temperature side.

A study of the failure, in 1946, of the 2-drum, 3-pass, waste heat boiler, operated at 150 psi on No. 1 roaster, led to the conclusion that it had been caused by a combination of corrosion and erosion.

Corrective measures were incorporated in the design of the boilers for No. 2 roaster. To minimize



Left: J. N. Ord, Acid Dept. Chief, and the author of this article. Right: No. 2 acid plant. Except for the control room housing rectifiers for the mist precipitator, all construction is outdoors. Roaster building in right background.



The operator's office at No. 2 roaster provides instrumentation, audible and visual signals, diagram showing flow of material.

corrosion attack, it was decided to generate steam at 450 psi, which provided tube and drum wall temperatures well above the acid mist dew point. The drums were located out of the direct flow of the dust laden gases to protect them from erosion. In order to cut down tube erosion, gas velocity by the tubes was reduced by adopting a single pass design.

Regular inspections show that all tubes and drums are in excellent condition after four years of operation at 450 psi. The high pressure steam is utilized in a stripping turbine on the No. 2 acid plant blower with exhaust steam at 150 psi entering the plant service main.

From the boilers the gas passes through cyclones and hot fans after which the two streams join before entering three parallel Koppers-Ellex electrostatic precipitators. Dust collected throughout the gas system is returned to the chamber hearth and at full capacity amounts to 50 pct of the ore feed.

Roasted ore is drawn from a bin by star feeders into two parallel United Conveyor Corp. 30 in. diam by 7 ft long conditioners which add 10 pct moisture, and deliver the ore onto a collector belt conveyor. Other zinc materials may also be fed from bins onto this collector belt. Coal at about 5 pct of the total feed is similarly collected. The collector discharges into a 12-ft long double-shaft paddle mixer where water is added and the materials are thoroughly mixed. The mix then passes through 24-in. diam, 30-in. wide flaking rolls, emerging as flakes which are the nuclei for pellet formation.

The pelletizer is 10 ft diam, 14 ft long slightly pitched, and rotates at 4 rpm. The material is tumbled and rolled to form pellets varying in size from 1/16 to ¼ in. A small amount of water is added in the pelletizer to give the close moisture control necessary.

Pelleted charge at 25 tons per hr is then fed through an oscillating chute onto a 1 to 2 in. hearth layer of coarse sinter on the pallets of a 72 in. wide, 97 ft long American Ore Reclamation Co. sinter machine. The charge is ignited as it passes under a 6-ft long, oil-fired combustion chamber. Windbox area is 432 sq ft. Suction is supplied by a 700-hp fan.

Sintered material is discharged through slugger rolls set with a 2-in. gap and then screened on a Hummer screen, with ½ in. oversize being returned as hearth layer and undersize comprising the product. A fraction is recirculated when desired and the balance is milled to proper size for the smelting operations. Conditioned with 2 to 3 pct moisture to prevent dusting, the product is shipped in hopper bottom cars to the slab zinc dept. and the American Process oxide dept.

Dust-laden gases from the sinter fan, carrying some zinc, lead, cadmium, and other metal values, pass through a settling and humidifying chamber for removal of the coarser particles and for adequate humidification prior to entering a rod curtain type Cottrell electrostatic precipitator. Exhaust is through a 300-ft stack. Collected fume is removed by dust-tight conveyors to a rotating oil fired calciner where it is densified to reduce handling problems in delivery to smelters.

Sulphuric Acid

The No. 1 acid plant, rated at 100 tons H_2SO_4 per day, has, prior to conversion, a gas purification system consisting of scrubbing tower, lead pipe coolers, drying tower and coal, coke and mineral wool filters. Two Roots-Connersville blowers in parallel are the prime movers. The converter is a two-stage unit with the heat exchangers within the same shell. Platinum catalyst is used, with silica base pellets in the first stage and magnesium sulphate base pellets in the second. Conversions over a long period of time have averaged 95 pct. Absorption takes place in two parallel towers. Products are 66° Bé H_2SO_4, 99 pct H_2SO_4 and 20 pct Oleum and intermediate grades by blending.

The No. 2 acid plant is a standard Leonard-Monsanto 240-ton H_2SO_4 per day capacity plant with a Peabody scrubber. Mist Cottrells take the place of the filters used in No. 1 plant. An Elliot blower driven by a 450-hp motor and steam turbine is the prime mover. A three-pass converter uses vanadium catalyst and effects conversions averaging 97 pct. Two grades of acid are made—66° Bé H_2SO_4 and 99 pct H_2SO_4, taken from the drying and absorbing circuits respectively. The SO_2 content in the 66° acid is reduced to shipment specifications by passing the product acid through a Peabody stripping tower into which 400 cfm of air is blown.

A waste water treatment plant automatically neutralizes any acidity in the effluent, removes solids, and assures compliance with the Pennsylvania State program for clean streams.

Various phosphorescent and fluorescent pigments are produced by adding activators and other reagents to sulphides of zinc, cadmium, calcium, and strontium. The prepared base pigments are muffled under careful control to impart luminescent properties, then disintegrated, screened and packed.

Roasted ore and suitable zinc byproducts are the sources of zinc for the production of zinc sulphide. Treated with dilute H_2SO_4, the zinc is dissolved as $ZnSO_4$, which undergoes purification steps of oxidation and reduction to eliminate contaminating metals. The purified $ZnSO_4$ is treated with H_2S gas generated by the addition of H_2SO_4 to sodium sulphydrate, and ZnS is precipitated. After a succession of filtering, washing, and drying steps with addition of reagents and with final muffling, wet milling, filtering, drying, and disintegrating, the pigment is ready to be packed in bags for shipment.

Typical Green Ore Concentrates

Source	U.S.	U.S.	U.S.	Can.	Mex.	S.Am.	S.Am.
Zn	59.5	48.4	56.7	53.0	47.6	47.8	61.1
Pb	0.9	0.8	0.3	3.6	1.1	2.6	0.4
Cd	0.11	0.26	0.13	0.19	0.61	0.15	0.16
Fe	2.5	13.5	5.6	4.0	14.3	11.5	1.9
Cu	0.03	1.0	0.7	0.8	0.3	0.1	0.3
As	0.002	0.03	0.003	0.044	0.04	0.13	0.02
CaO	1.5	0.1	1.0	0.7	0.3	0.1	0.01
SiO_2	0.2	0.2	1.9	1.1	0.8	1.1	1.7
S	30.9	33.4	31.0	31.2	31.9	31.8	31.5

Slab Zinc Dept.

by H. C. Haupt

THE first commercial continuous zinc smelting process was placed in operation at Palmerton, Pa., in 1929. This process, known as the vertical retort process, was described by E. H. Bunce and E. C. Handwerk in the AIME *Transactions*, 1936. The new process achieved savings in labor and fuel, with higher zinc recovery and improved working conditions. Production requirements at Palmerton were such, however, that a part of the old horizontal retort reduction furnace plant continued to operate until after World War II. In 1950 the last of the horizontal furnaces was replaced by a vertical retort plant incorporating the latest design features.

The essential steps in the process are as follows:

1. Preparation of the charge:
   - (a) Mixing ore with reducing agents and binder.
   - (b) Briquetting and coking.
2. Reduction of the charge.
3. Condensation of the zinc vapor.
4. Casting into slabs.

At the acid dept. sulphide ores are roasted, sintered, and ground to the size which develops optimum briquette strength for coking and smelting. Oxide ores may be used without treatment other than grinding, although a calcination step may be desirable for certain materials.

Charge Preparation

Ore is blended in a rotary mixer with anthracite dust and finely ground bituminous coal. The bituminous coal is carefully selected on the basis of its coking ability to form briquettes which will retain their shape throughout the reduction operation. Slack, pea, nut, and run-of-mine grades are crushed in a hammer mill and ground in an open circuit conical ball mill.

A binder, such as sulphite waste liquor, is added to the coal and ore and the mixture is kneaded and densified in a series of two or three Chilean mills. The mix then passes through (1) a paddle mixer for final moisture adjustment, (2) a densifying roll briquette press, and (3) a final briquette press. Briquettes are fed directly and continuously to the coking furnaces.

In the original design, the coking was accomplished by bringing the briquettes into direct contact with the exhaust combustion gases from the reduction furnaces. In the most recent design, the coking is autogenous with the heat requirements being met by the combustion of the volatile matter from the bituminous coal. The exhaust gases from the coking furnaces are passed directly to stacks.

H. C. Haupt, Slab Zinc Dept. Chief.

Briquettes leave the coking chamber continuously, but are held in closed hoppers from which they are drawn on the charging cycle for the reduction retorts.

The briquettes leave the coking chamber continuously but are held in a closed hopper from which they are periodically drawn on the charging cycle for the reduction retorts. The hot, coked briquettes are discharged over a grizzly and into charge buckets for elevation to the charging level of the retorts.

Reduction

A battery normally comprises eight retorts, each with its own combustion chamber in a setting of silica refractories. The retort is essentially a tall gas tight structure rectangular in cross section with its walls formed of silicon carbide refractories for high heat conductivity. The long walls of the retort fit into slots in the end walls which are provided with glands filled with granular silicon carbide and graphite. Slip joints are thus formed that are impermeable to zinc vapor while permitting the walls to expand and contract independently. Like the coking furnaces, the retorts have been radically changed in recent years and increased capacity has been realized by extending both the height and length.

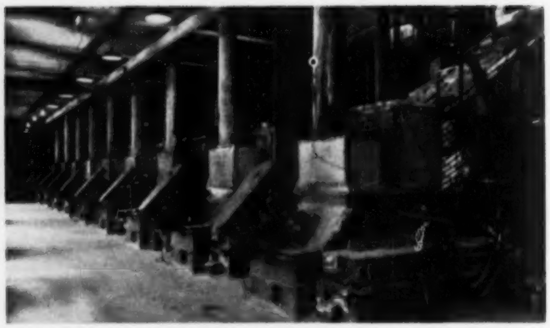
The retorts are fired externally at 1300°C with producer gas. The gas enters the combustion zone at the top and the preheated air for combustion is admitted at various levels in controlled amounts to insure uniform heating over the entire wall.

Retorts are operated continuously but the charge is introduced batchwise. The upper extension of the retorts has sufficient capacity to insure a continuous flow of briquettes to the reduction zone throughout the charging cycle. The charging must be interrupted for about 24 hr every 8 weeks to permit the removal of zinc oxide accretions from the walls of the upper extension.

Spent briquettes are continuously discharged from the retort by a roll extractor into a water seal. The quenched briquettes are removed by an inclined screw conveyor to a traveling belt conveyor which delivers into gondolas for disposal.

The combustion gases are exhausted at the base of the heated zone and enter a counter-current recuperator. The waste gases from all the recuperators in a battery enter a common flue and are moved by an automatically regulated induced draft fan.

Displacement air under slight pressure is admitted to the bottom extension of the retort. This air maintains an upward flow of gases and vapor through the



Working conditions at these zinc vapor condensers are excellent due to water cooled coils for heat removal. Condensation efficiency is over 96 pct.

retort to prevent condensation of the zinc in the lower extension. The zinc vapor and reaction gases flow continuously from the upper extension of the retort through an insulated flue to a splash type condenser which is thoroughly insulated and provided with automatic temperature and pressure regulation. Condensation is accomplished by bringing the vapor and gases into intimate contact with droplets of liquid zinc which are continuously splashed into the gas stream by the action of a graphite rotor partially immersed in the bath of zinc.

The zinc bath is automatically maintained at temperature of about 500°C by thermostatically controlling the duration of immersion of steel pipe coils through which cold water is flowing.

The pressure in the condenser is automatically maintained by controlling the water supply to a Venturi tube ejector which draws the gases from the condenser through a stack into a scrubber.

The working conditions at these condensers are excellent and far superior to the original air cooled baffle type design because the condenser is thoroughly insulated and the heat of condensation is extracted by the water cooled coils. Condensation efficiency is high. Over 96 pct of the zinc in the gases entering the condenser is recovered as metal. The remainder is recovered as skimmings, stack blue powder and scrubber blue powder, all of which is recirculated to the retort. The scrubbed gas from the condenser is returned to the furnace along with the producer gas and supplies over one third of the fuel requirements.

The condensed zinc overflows continuously from the individual condensers and is conducted by an insulated and heated trough to a collecting pot. It may be cast into slabs or transferred as molten zinc in ladles to the refining operation. Slabs are cast manually and formed into units of about 1½ tons for handling with fork lift trucks through a weighing station to storage and shipping.

Zinc Refining

The process* is essentially a two-stage fractional distillation. Lead and other high boiling point impurities are removed in the first stage and cadmium and other low boiling point impurities in the second stage.

Molten vertical retort zinc is fed by ladles to the feed pot, which serves to maintain a steady flow to the lead boiler. The vapor from the boiler ascends through a rectifying column where it is freed of lead and other high boiling point metals before entering the condenser. The feed rate exceeds the vapor output and the excess passes out of the bottom of the boiler to a run-off pot. Here the lead and iron are removed by liquation and the molten zinc is returned to the feed pot.

The condensate from the lead column condenser becomes the feed to the adjacent cadmium column. Here the bulk of the feed is refluxed to the base of the column, free of cadmium and low boiling point impurities, and is collected in the refined metal pot. The metal is 99.99+ pct zinc and is marketed as the Horse Head Special brand.

Slabs are cast and formed into units of about 1½ tons for handling with fork lift trucks. Anodes for electro-galvanizing are produced in a variety of shapes to meet customer requirements.

Cadmium is removed from the cadmium canister in the form of cadmium-zinc metal and dust. Both byproducts are shipped to the Depue, Ill., plant for the production of cadmium metal.

Zinc dust is produced by redistillation of cadmium-free zinc from the refining operation. A fractionating column, placed ahead of the canister, removes lead and permits the production of high purity zinc dust.

The die casting alloys Zamak 3 and 5, developed by the research department, are produced by alloying Horse Head Special metal with aluminum, magnesium and copper.

* Readers interested in a more complete description of the process are referred to the paper by W. M. Peirce and R. K. Waring in A.I.M.E. Transactions Volume 121 (1936).

Metal Powder Plant

by R. A. Forner

THE metal powder plant at Palmerton was developed during World War II to make available zinc, brass, and copper powders. After a somewhat dormant period following the war, it now appears that the powder metallurgy industry is on the threshold of great expansion, affording many advantages in the production of mechanical parts.

The plant has been expanded and many kinds of powders are currently produced. They include 8 brands of zinc, 6 of copper, 18 of brass, 14 of brass with aluminum, 8 of brass containing lead, several bronzes, and nickel silver. The plant does not manufacture articles made from these metal powders but the services of the research dept. are available for technical assistance to parts manufacturers.

Metal powders are produced by atomization of a falling stream of molten metal using high pressure air. The plant is equipped with four Ajax-Wyatt 80-kw induction furnaces to provide molten metal as required for atomization. The induction type of furnace assures thorough mixing of the materials right up to the pouring stage. The chemical purity of the powder is determined by the quality of the metal used. The production line provides for as many as three furnaces to be in simultaneous operation, one continuously in the pouring position with the others being used for supplemental melting. Individual furnaces are readily moved to and from the production line by means of a monorail hoist.

The atomized metal is blown into a cylindrical steel receiver where it collects and cools and is then conveyed by Syntron feeders to Rotex screens. Rejects are returned to the melting furnace and the sized product is packed in steel containers.

Zinc Oxide

by W. A. Thomas and, W. A. Handwerk

American Process Oxide

This car shaker empties a 50-ton carload of incoming ore in 10 min with a minimum of dusting. The shaker is supported and moved by the structure on the bridge crane.

THE first product made at Palmerton, in 1899, was American Process zinc oxide. A charge of finely crushed oxidized ore from the Franklin mine was mixed with fine anthracite and smelted on Wetherill type furnaces. Over a period of years these furnaces* were improved and extended, reaching their maximum production during World War I when 72 blocks of 4 to 8 furnaces each were operated. In the early 1920's the more efficient traveling grate furnaces were developed and the gradual transfer of production to them has been practically completed.

Hopper bottom cars deliver sintered roasted ore, sintered Waelz oxide and fine anthracite to open stockpiles under a 50-ft high trestle. A Robins mechanical car shaker, mounted on a crane, and telescoping steel ore tubes aid in unloading these materials efficiently and with little dusting. Handling to mixer station is by a 7-ton bridge crane.

A charge of 80 pct zinc materials and 20 pct anthracite is batch-weighed, mixed in a rotary mixer, and fed at a controlled rate into two 12-foot diam Chilean mills in series. Sulphite liquor binder is added and the mix thoroughly kneaded to prepare it for briquetting. A pair of briquette rolls form pillow shape briquettes 2 in. square by 1½ in. max depth which discharge over a grizzly where fines are removed for return to the press feed, the green briquettes being carried on a continuous horizontal screen tray conveyor through a direct fired dryer. Dry briquettes are stored in overhead bins for transfer by larry car to the furnaces.

Coal briquettes are similarly prepared using dried anthracite mixed with sulphite liquor binder in a paddle mixer, and processed in a single Chilean mill prior to briquetting and drying.

In the operation of a traveling grate zinc oxide furnace* coal briquettes, delivered by larry car to the furnace hopper, are fed onto the slowly moving grate, pass under a leveler, and are ignited by radiant heat in the *coal chamber*. Air in regulated amounts is blown up through the grate. A layer of ore-coal briquettes is similarly laid on top of the burning coal briquettes and, after passing under another leveler, enters the smelting zone of the furnace. Combustion of the coal briquettes supplies the heat required to reduce the zinc oxide in the ore briquettes. Furnace residues are continuously discharged to cars for removal to the refuse bank.

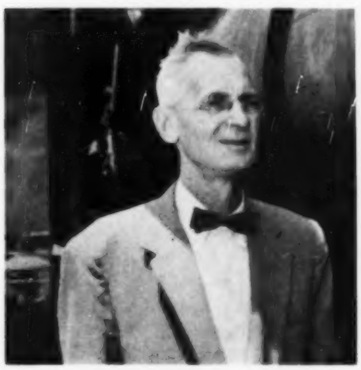
The zinc oxide fume, along with the fuel products of combustion, is drawn from the combustion system into pipe lines by means of the hot fans which push the fume through other pipe lines to the bag house. Cooling air is admitted to the pipe lines through regulating doors on suction side of hot fans to control hot fan and filtering bag temperatures.

The bag room is the overhead conventional branch row type, with 22-in. diam bags connecting to hoppers and canvas collecting bags on ground floor. The top section of the bag is a 17-ft asbestos tube. The lower section is a 28-ft muslin tube. Temperatures in pipe lines entering bag house are about 300°C.

To improve such properties as color and brightness, or to densify, or to increase particle size, some of the oxide is given a controlled heat treatment in a 7x60-ft brick lined rotary kiln direct fired with an automatic controlled oil burner. Oxide from the kiln is cooled in water jacket conveyors, Mikro-pulverized, and conveyed to a holding bin for transfer to the packing house.

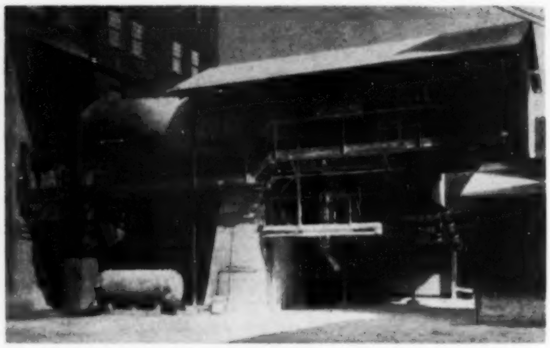
Improved properties of zinc oxide for rubber compounding, such as speed of processing and higher reinforcement values, are obtained by coating each particle of zinc oxide with zinc propionate. This treatment is accomplished in a steam jacketed stainless steel mixer of special design where the oxide is kept violently agitated by paddles on a horizontal shaft. The oxide is humidified with steam, treated with propionic acid vapor and then passes through a Mikro-pulverizer to the holding bin. This Protox zinc oxide is packed on St. Regis automatic packers.

* Described in paper by E. H. Bunce and H. M. Haslam: Direct-process Zinc Oxide, AIME Transactions, 1936.



The authors of this section are (left) W. A. Handwerk, Chief of the Oxide East Dept.; and (right) W. A. Thomas, Chief of the Oxide West Dept.

Traveling grate furnace used in production of American Process zinc oxide.



Photograph shows the firing end of the 7x60-ft kiln used for oxide reheating.

Due to sulphur content of coal and sintered ore used in making American Process oxide it contains a small quantity of water soluble salts. Treatment of certain grades in the washing plant removes a considerable quantity of these salts, increasing the rate of cure when the oxide is used in the manufacture of rubber and thus imparts to American Process oxide characteristics commonly found only in oxide made from zinc metal. The plant consists of tanks where oxide is slurried with filtered water and ammonia, agitated and filtered on a rotary filter, the filter cake being washed with hot water. The cake in form of strudes is dried on a steam heated endless basket type conveyor. The dried strudes are surface treated, Mikro-pulverized, and delivered to a holding bin for transfer to the packing house.

To produce less bulky zinc oxide that is free flowing some bag room oxide is pelletized in a rotary drum. The pelleted product is largely −8, +30 mesh with about 60 lb per cu ft bulk density.

The oxides delivered to packing house are sampled and blended and passed through Rotex sifters to packing machines. The 50-lb bags are formed into 1 to 1½ ton units in shapers. The units are transported to a hydraulic press and taken to storage or shipment car by lift trucks.

A sample is automatically drawn from each bag of oxide and composited by a unique screw conveyor sampling device recently built into all packing machines. Before the bags of oxide are delivered to the storaging and shipping div. these samples are graded for approval of the brand packed.

Waelz Process Oxide

The Waelz process, developed in Upper Silesia in 1923, is a satisfactory method of concentrating low grade oxidized zinc ores and has been used by New Jersey Zinc since 1929. The zinc content of the materials furnaced ranges from 5.0 to 20.0 pct and the product averages about 60 pct zinc. Up to 1000 tons of materials are treated daily in three kilns, production being largely dependent on zinc content.

The furnace is a long brick-lined steel cylinder, much like a cement kiln, which turns one revolution in about 90 sec. Ore mixed with coal for firing and reduction flows through the kiln countercurrent to the gas and air flow. The gas carrying zinc oxide and fine particles of charge passes through a dust catcher and pipe lines to a bag room, where the oxide is collected and transported to the sinter plant.

The charge consists of 75.0 to 80.0 pct ore and 25.0 to 20.0 pct coal, depending upon the nature of the ore. Materials used include not only low grade ores from Franklin and Sterling mines but also various zinc and carbon bearing byproducts and residues from the Palmerton operations. Size of the ore is important and a minimum of +14 mesh is desirable. The fuel is fine anthracite.

Constituents of the charge are gathered from stock bins on 7-ton weighing larry cars and elevated to a 50-ton feed bin ahead of each kiln. The rate of feed is controlled by regulating the speed of the conveyors which draw the mixture from the bins and deliver it to inclined steel tubes leading into the kilns.

Three kilns are in service: two are 160 ft long by 11 ft 3 in. diam and the other 140 ft by 10 ft diam. They are inclined about 3 pct of the kiln length. Each kiln is motor driven and is also equipped with an auxiliary steam engine for use in emergencies. The kiln lining is 6 in. of first quality fire clay brick for 60 ft at the feed end, and for the remaining length is 9 in. of Harbison-Walker Super-Duty Kenmore fire brick. The life of the brick lining is relatively brief at the hot zone but may reach several years at the feed end.

The feed end of the kiln is sealed into the dust catcher and the discharge end is sealed into the firing hood. An observation room is provided at the discharge end where control instruments and auxiliary heating units are located. The heating units consist of two Aero and one Babcock-Wilcox bituminous coal pulverizers, and oil burners.

The charge, which takes about 2 hr to pass through the kiln, reaches the temperature required for reduction in less than one-third of the length of the kiln. The reducing and oxidizing zones do not follow each other but are actually superimposed over the whole length of the reaction zone. The heat developed by the reactions inside the kiln is usually sufficient to maintain the temperature required for the reduction of zinc. Additional heat if needed may, of course, be supplied by the burners but the company has developed a method, usually applicable, which depends on directing a blast of air on the charge near the discharge end of the kiln to oxidize unburned carbon and reduced iron.

Draft is supplied by fans located between the kilns and the bag rooms. Three 30,000-cfm fans, driven by 75-hp variable speed motors are used for each of the large kilns and two for the small kiln.

Exit gases, fume, and fine particles of dust leave the kilns at about 600°C. Heavy particles of dust are removed in the dust collecting chamber and are recirculated to the kiln. Sufficient cooling air is admitted through adjustable openings located in the

suction side of the pipe lines to reduce the temperature of the fume and combustion gases to below 200°C before entering the bag room.

The muslin filter bags are 22 in. diam and 39 ft high, about 340,000 sq ft of filter area being required for the three units. The bags are manually shaken every 2 hr. The oxide is dumped from the collecting hoppers into tote boxes which are transported to the sinter plant by a Towmotor lift truck.

The clinker from the kiln falls into a quenching pit, from which it is conveyed to a chute leading to a railroad car. The clinker production contains iron and manganese values, and depending upon the analysis, is used by the spiegel dept. to produce spiegel-iron or finds an outlet in the steel industry.

Successful operation of the Waelz Process as applied to the ores used at Palmerton depends largely upon keeping the charge metallurgically dry, that is, free from slagging. This is accomplished by a careful blending to yield a mixture definitely on the basic side. Experience has indicated that the lime to silica ratio should be 1.5 to 1.0 for most ores treated.

The formation of accretions in the kiln is characteristic of this type of Waelz operation. Such accretions protect the lining and promote charge retention time, being beneficial as long as they do not adversely affect the draft or impede the flow of material. When such a stage is reached the rings can sometimes be reduced by radical changes in the draft, or by temperature shock induced by chilling with water and rapid reheating. Obstinate rings may be removed by Cardox inserted through port holes in the kiln shell extending through the brick lining. When such methods are unsuccessful, the kiln is shut down and the accretions are dynamited.

For efficient utilization by the smelting operation, the Waelz oxide is sintered on a 3½x33-ft wind box Dwight-Lloyd machine. Sintering practice parallels that for sintering roasted ore at the acid dept.

Leaded Oxide

Several brands of leaded zinc oxide are made of varying lead-zinc ratios ranging up to equal parts of basic lead sulphate and zinc oxide. Some products are co-fumed; others are mixtures incorporating desirable properties of various American Process zinc oxides.

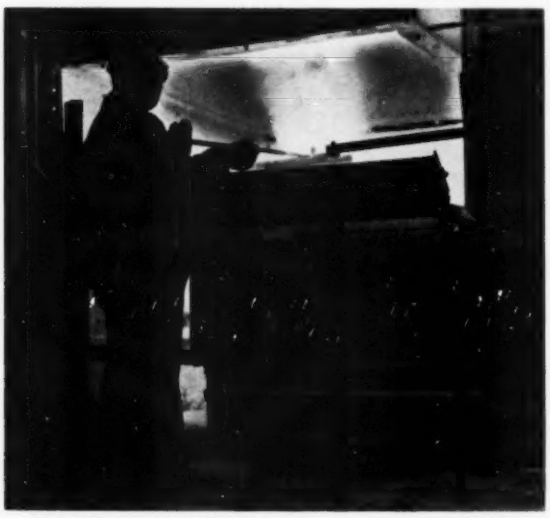
The lead sulphate and co-fumed product are made on a traveling grate furnace similar to the American Process zinc oxide furnaces, but utilizing a high quality galena as raw material.

It was early recognized that a health hazard exists in the production of fumed lead sulphate and at Palmerton precautionary measures were established which have been carefully followed. Most important of these is the absolute insistence on respirator protection for all work done in areas where lead-containing dust may be found. Other important precautions are the furnishing of work clothing and the laundering of it, the enforcement of cleanliness in preparing to eat and to don street clothing, regular sampling and analysis of workmen's blood and urine, and routine medical examinations. The results of this program have been very satisfactory.

French Process Oxide

French Process zinc oxide is produced in a furnacing plant with three gas fired columns, two for the removal of lead and one for cadmium, similar to the slab zinc refining columns. Gas is made in two 10-ft Galusha producers using anthracite fuel.

Metal used is received by railroad, usually in the form of 1½-ton units of 40-lb slabs which are handled by a Towmotor lift truck. Molten metal is fed to the cadmium column where any cadmium contained is removed as a cadmium-zinc powder byproduct. The powder is screened through 12 mesh, the undersize is packed in bags, and the oversize is melted and cast. Both byproducts are shipped to the Depue, Ill., plant for production of cadmium metal. The cadmium-free zinc discharges at the base of the column into a holding pot and in its molten state is rehandled to the feed pot of either lead column. The lead columns remove the heavy metal impurities by refluxing and the purified zinc vapor is burned to zinc oxide.



Pure zinc vapor being burned under controlled conditions to make French Process oxide.

Two separate oxide collecting systems are provided for each of the two vapor columns. Four motor driven fans rated at 30,000 cfm deliver the oxide at temperatures below 125°C through 36 in. diam steel flues to bag rooms equipped with muslin bags 22 in. diam by 39 ft long. About 300,000 sq ft of filtering area is provided. The bags are shaken twice on each 8-hr shift. The oxide is taken from the bag hoppers to the packing house in collect bags on tractor drawn trucks. A Wheelabrator automatic bag room is successfully handling its designed capacity for about 25 pct of the production.

At the packing house the oxide as collected is blended if necessary, screened, and packed 50 lb per paper bag. Howe auger packers are used. At the packers the bags are formed into 36 to 48 bag units, and transported by Yale and Towmotor lift trucks to press, storage, and shipment by truck or rail, all with no necessity for use of pallets.

The physical properties of the oxide may be controlled over a wide range by varying the combustion conditions, and oxide of the highest chemical purity can be produced.

Spiegel Dept.

by C. E. Grimes

C. E. Grimes, Spiegel Dept. Chief, and author of this article.

AS early as 1770 the ore deposit at Franklin, N. J., was looked upon as a source of iron. Shortly after production of zinc oxide from this ore at Newark, N. J., began in 1852, efforts were made to profitably recover the iron and manganese from franklinite. The resulting spiegeleisen or spiegel had small use at the time but shortly afterward the Bessemer process for making steel opened a market for all the spiegel that could be produced.

The production of spiegel at Palmerton has been carried on since 1904. The residuum from the zinc oxide furnaces and Waelz kilns working franklinite ores is charged into blast furnaces with coke and limestone, and the smelting operation is similar to iron blast furnace practice.

The residuum contains about 40 pct Fe, 14 pct Mn, 10 pct SiO_2, 5 pct Al_2O_3, 1 pct Zn, and varying amounts of calcium, magnesium, and carbon. The latter is carried along from the previous smelting operation which uses fine anthracite as fuel. With each ton of residuum about ½ ton of coke and ⅛ ton of limestone are charged into the furnace.

The use of this residuum, containing over 1 pct of zinc, as the sole manganiferous constituent of the charge brings about some unusual operating problems not encountered in ordinary blast furnace practice. Some metallic zinc vapor penetrates the brick lining and the balance reoxidizes in the upper part of the furnace where it occasionally cements the charge sufficiently to cause it to hang up. It also forms a shale-like *rock oxide* which tends to block the downcomers and the Theisen washers used to clean the gas before burning in the hot blast stoves and under boilers.

Because the reduction of manganese requires a high temperature and direct coke contact, the coke consumption is high in comparison with normal blast furnace practice and the gas leaving the top is higher in CO and lower in CO_2 than in most furnaces. The furnace top temperature is higher than in pig iron furnaces, which causes undue warping of bells, hoppers, downcomer pipes and fittings.

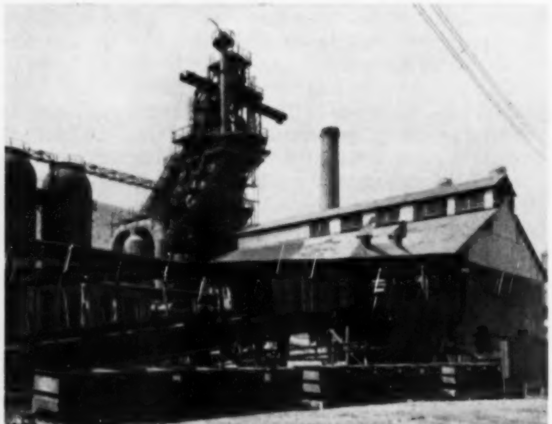
The plant consists of two furnaces on 245-ft centers on an east-west line with the hot blast stoves, gas cleaning equipment and stock pockets to the south, and a coke storage space south of the stock pockets. Reserves of limestone and residuum are stocked elsewhere. The 60-ft wide cast houses extend 110 ft north of the furnace centerline. Croxton slag pits with an overhead crane to serve them and the pig casting machine fill the space between the cast houses. Three blowing engines are located in the plant power house just west of the furnace area. Layout is compact and all the operators of auxiliary equipment are close to the furnaces.

Until 1938 all of the spiegel was cast in sand beds in the cast houses. Due to the ease with which spiegel can be broken and removed from sand beds, the installation of a pig casting machine was not particularly attractive until there developed a preference by the trade for pigs free from burned sand crusts. This factor, combined with rising labor costs, led to the installation of the pig casting machine.

The single casting machine used to serve the two furnaces is 160 ft between shaft centers and the molds travel slowly, about 15 fpm, in order to give cooling time on the machine. A 50-ton ladle on a car is moved between the two furnace casting spouts at the cast houses and the pouring stand by a rope haulage, and the cars holding the cast pigs are also moved along under the chute by means of a rope haulage. This eliminates the need for constant locomotive service at the furnaces.

It was soon found that quenching the spiegel in a railroad car after it left the machine was impractical as the pigs cracked and cross-fractured badly and created a subsequent handling problem.

The pigs were then dropped into steel cars and allowed to air cool before being transferred to ship-



Spiegel plant view shows blast furnace, stoves, slag craneway, discharge end of casting machine, and tote boxes on cars ready for pig handling.

Ross-Carrier lift truck and tote boxes of special design are used in handling spiegel—hand work has almost been eliminated from this operation.

ment cars. This required each pig to be handled by hand whether it was shipped immediately or put on the stockpiles. Spiegel cannot be handled with a magnet as it is only slightly magnetic and the use of a locomotive crane and clamshell bucket on this material cost more than hand handling.

Finally a unique handling method was developed. The pigs slide down the pig machine chute into bottom dump steel boxes, holding about 7 net tons each, placed on flat cars. After a cast is finished a 9-ton lift truck of special design, built by the Ross Carrier Corp., removes the boxes from the car and places them on the ground for the pigs to air cool and puts empty boxes back on the cars.

By the time the spiegel is cool the analysis is known. The lift truck then picks up the boxes and either dumps them through the bottom into a car for shipment or onto a stockpile of the proper grade.

The only pigs now handled by hand are those moved from the stockpiles for shipment. These are loaded into similar, but lever sided, boxes placed near the piles and are then moved by a lift truck.

The Rolling Mill

by M. A. Powers

M. A. Powers, Rolling Mill Chief, is shown here with some of the products from this department.

THE company's entry into the zinc rolling business in 1917 was primarily to broaden the outlet for zinc metal. The original plant was equipped with one roughing and two finishing mills, each with rolls 28 in. wide and 17½ in. diam. With no commercial experience in rolling zinc there was much to be learned, but initial problems were rapidly overcome and within 2 years the addition of another roughing mill and three finishing mills brought the plant capacity to about 4000 tons per year.

Improvements in auxiliary equipment and processes have since been made and the annual productive capacity has been more than doubled. Each order is individually rolled for the customer's particular requirements.

The processes for the rolling of zinc are similar to those used for other nonferrous metals. The melting and alloying of the zinc is accomplished in coal fired reverberatory furnaces ranging in holding capacity from 5 tons to 50 tons. The furnaces are constructed in such a manner that the metals may be charged with a minimum of oxidation and volatilization.

The zinc at a temperature of 460° to 490°C is poured from transfer ladles into horizontal molds which have water-cooled bottom fins and top heaters. Careful attention is paid to mold temperatures, dressing of the molds, rate of pouring and removal of dross before freezing of the zinc occurs. Castings are made in sizes up to 2 in. thick, 22 in. wide and 90 in. long. The castings after storage in a furnace at 180° to 210°C, mainly to equalize the temperature, are ready for rough rolling.

This view shows a crew starting a pass at a strip roughing mill. A variety of products is made in a wide range of gauge, width, length, and physical specifications.

The rough rolling or breaking down of the cast bar is accomplished on 2-high mills with rolls maintained at temperatures between 100° and 200°C. The slabs may reach temperatures as high as 275°C while they are being broken down from 1½ in. or 2 in. to 0.070 in. Any necessary hand scraping of surface defects is performed during the rolling. The rough rolled metal may be finished plate, sheet from which slugs are punched, or coils to be further processed on the finishing rolls.

Rough rolled coils are taken hot or at room temperature and rolled on the finishing mills to the required gauge, which is generally from 6 pct to 50 pct of that of the rough rolled coils, in from two to eight passes.

In general, high temperatures and heavy reductions will produce a hot rolled product of small grain size, low hardness and temper, and high ductility with good bending properties. Cold rolling and light passes will produce greater hardness, high tensile strength and temper, with lesser ductility and poorer bending properties.

Improvements to the strip finishing rolling operation have brought about a higher rolling efficiency and better product quality. They include magnetic type of automatic gauging, automatic tension winding, and motor driven screw downs with push button control. Smoother roll speeds have been obtained by using universal spindles in place of wobblers formerly used on the drive.

Metal from the finishing rolls is slit, sheared or sawed. Slugs and discs are punched out on blanking presses. Throughout the entire processing the product is under careful control.

Packaging is done with containers lined with waterproof paper, and thoroughly dried lumber is used to prevent surface staining of the zinc. There has been a gradual transition to shipment in economical, returnable containers holding up to 3500 lb with built-in skids so that the load can be handled by fork lift truck.

Service and Maintenance

by H. E. Breit

H. E. Breit, the author of this article, is Service and Maintenance Dept. Chief.

SERVICE and maintenance at the Palmerton plant encompasses a wide variety of duties. Among the many services rendered are steam, power, water, railroad, locomotive crane, refuse disposal, sewage, fire protection, inspection, supplies, trucking, pyrometric, and shops. To perform these services a work force of 585 men is required.

Steam is generated at two boiler houses. The main boiler house, at West plant, which supplies steam for power as well as heating and process, has 16 boilers, i.e. four 670-hp Babcock & Wilcox straight tube and twelve 536-hp Edgemoors. Three of the latter have been converted from coal to blast furnace gas. The boiler house at the East plant consists of four 502-hp Sterling type units.

Coal, burned on Coxe traveling grate stokers, is nominally a No. 3 Buck anthracite, but coming from various culm banks and mines there is a wide variation in screen analysis. A typical composite shows up to 10 pct +3/16 in. and as high as 50 pct −3/32 in. Ash runs about 22 pct and heat value about 11,300 Btu per lb dry. West plant coal is delivered in gondolas to a trestle, thence by gantry crane to elevator boot or stockpile. Elevators discharge into bins in the boiler room from which an overhead weighing larry distributes to individual boilers. Ashes are dumped directly from hoppers to railroad cars. East plant coal is delivered by car or truck to a pit, thence by monorail crane to boilers or to stock. Ashes are discharged into refuse cars.

The quality of blast furnace gas is somewhat unique due to the nature of the furnace charge. The gas is high in dust, 0.4 gr per cu ft, and low in heat value, 120 Btu per cu ft. Peabody burners with oil ignition are used. Anticipated dust difficulties led to alterations of the first two boilers converted, the number of passes being changed from 4 to 2, but operating experience indicated this was unnecessary and the third boiler was not altered. A much lower exit gas temperature resulted in improved economy.

Augmenting the East plant boiler house is an installation of two Babcock & Wilcox waste heat boilers, which utilize the heat in gas from No. 2 zinc concentrate roaster at the acid dept. Each boiler has 6600 sq ft of heating surface, and is designed for 700 psi pressure. Operation has been at 450 psi. Reduction to distribution pressure is accomplished by passing the steam through a turbine driving the acid plant blower.

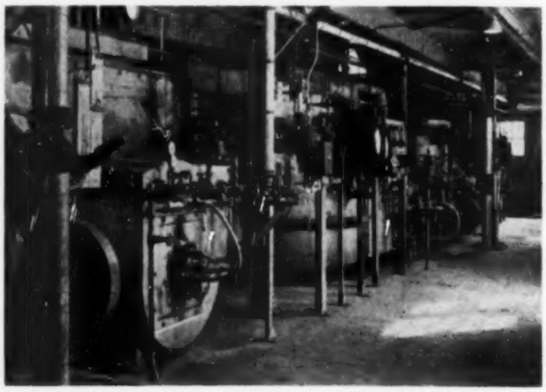
Boiler feed water is almost entirely make-up. Soft, clean, raw water is used at the West plant but at East plant sand filters and zeolite softeners are used. Scale and sludge troubles have been eliminated by internal treatment with phosphate and soda ash as set up by Hall Laboratories Inc.

Power requirements run from 10,000 to 14,000 kw, of which roughly 55 pct is generated and 45 pct purchased. The two systems are isolated and when, as infrequently happens, a block of load is transferred a momentary interruption is involved. Generation is by five condensing turbo units ranging from 2000 to 5000 kw capacity. Transmission is at 6600 volts with distribution at 440 v from transformer stations made up of 1500-kva banks of three 1-phase units. A transmission line of five circuits on two sets of steel towers connects the plants. Purchased power is brought in by the Pennsylvania Power & Light Co. over two 66,000-v circuits to a station consisting of two 7500 kva, 3-phase, 66,000/6,600-v transformers.

Electrical work, including new installations and all motor rewinding as well as general maintenance is handled by a group of about 70 men.

Plant water requirements are taken from three sources. A 30-in. pipe line 3¼ miles long brings water from a dam on the Pohopoco Creek to pumps at the power house, and pumps at the East plant take from the adjoining Aquashicola Creek. The

Plant service involves four 115-ton diesel locomotives and 238 cars operating on 35 miles of standard gauge track.



Blast furnace gas is burned at the boilers in Peabody equipment. Due to nature of furnace charge, gas is high in dust.

Lehigh River is used for turbine jet condenser water. There are five 3500-gpm pumps, three being located at the West plant and two at the East plant. Three 2 million gal tanks located on a hillside and connected to each plant maintain a constant head and provide a few hours reserve supply.

Railroad service involves the operation of 35 miles of standard gauge track, four 115-ton diesel locomotives, and 238 cars consisting of hoppers, gondolas, air dumps, boxes, tanks and flats. Foreign cars are interchanged with the C.N.J.R.R., the L.&N.E.R.R. and the Chestnut Ridge Ry. The latter handles all traffic between plants as well as most incoming and outgoing shipments. Locomotives are manned by five-man crews and make from 400 to 500 total placements and releases per day.

A fleet of four 15-ton steam, two 25-ton diesel mechanical and one 40-ton diesel electric locomotive cranes operated by two-man crews unload and rehandle ore and coal and miscellaneous jobs.

The dieselization program for locomotives and cranes will be completed upon receipt of a 25-ton locomotive crane now on order. Marked economies in fuel, maintenance and efficiency of operation have been realized by substitution of diesel for steam equipment.

Refuse disposal is a major problem at any smelter but the company is fortunate in having an almost unlimited facility immediately adjacent to the East plant along the Blue Ridge mountain. A diagonal track up the side of the hill with grades of not over 3 pct leads to the top of the bank, at present some 240 ft above the plant. Upwards of 15 million cu yds of refuse have now been stocked, and by extension and back tracking, this area can be made to serve far into the future. Refuse is handled by 23 60-cu yd capacity tilting body type Magor air dump cars which within the past year replaced 40 64-cu yd manually dumped drop bottom cars. The air dump cars are emptied by the locomotive crews and are immediately returned for reloading. A D-8 Caterpillar dozer with a 12-ft blade moves the refuse from the dumping track to the edge of the bank.

Magor cars and a Caterpillar bulldozer dispose of refuse at the cinder bank. Heat remaining in water-quenched spiegel slag is sufficient to cause steaming when the carload is dumped.

Maintenance work beyond the scope of the various departmental repair gangs is handled by a shops group of about 270 men. A machine shop, recently modernized by replacement of a number of old machine tools and the elimination of all belting by individual drives, is able to handle jobs up to a complete locomotive overhaul. A tinker shop fabricates all manner of sheet and plate objects. Complicated bends and transition pieces in pipe work up to 5 ft diam are common shop jobs. A group of 16 electric and acetylene welders is attached to this shop, as is also a group of car repairmen. Masons form one of the larger groups, the wide variety of furnaces demanding a continuous and considerable program of refractory replacement and furnace rebuilding. A foundry produces iron and nonferrous castings of various mixes. A well-equipped carpenter and pattern shop, a blacksmith shop with mechanical and steam hammers, a pipe fitter group, and a paint shop provide other essential services.

Testing Dept.

by R. G. Mercer

IN the early 1900's most of the ore used at the Palmerton plants came from the Franklin mine. This ore was of a uniform high quality and smelter products were made with a minimum of chemical control. Today the plants use concentrates from many areas and it is necessary to know their composition accurately in order to use them efficiently and make quality products. These products, furthermore, are of greater variety than formerly and special tests of many kinds must be applied to insure their suitability.

The testing dept. is therefore more than just a chemical laboratory; there are now separate divisions giving specialized service on sampling and raw materials, products inspection, and storing and shipping. Service is provided not only to the local operating departments but also to the company's sales, research, and geological depts.

The sampling and raw materials div. inspects, samples, and prepares for analysis incoming coal, coke, ore, concentrates, and other metal-bearing materials, and makes sieve tests of purchased raw materials and manufactured products. Over 300 scales in use at Palmerton are periodically inspected and maintained by this division.

R. G. Mercer, Testing Dept. Chief, is seen in part of the extensive laboratory.

Each carload of concentrates is sampled with a hollow steel tube at 12 fixed locations, a representative car sample is made by careful mixing, moisture is determined, and the sample is prepared for chemical analysis. Composites of several carloads are often made on a net dry weight basis prior to preparation for the laboratory. Frozen cars are weighed and sampled after passing through a thaw house.

The laboratory with a force of 30 chemists and analysts supplies service on purchased materials, inprocess materials, finished products, and on samples

connected with research investigations, some 12,000 analyses being made in a typical month and 36 elements determined.

Classical methods of chemical analysis, while still the backbone of the laboratory methods, have been replaced to a considerable extent by such instruments as the polarograph, spectrograph, and electrophotometer. Five polarographs and two electrophotometers in regular use have greatly reduced the time required for many analyses.

To determine the suitability of a zinc concentrate for chemical or metallurgical processes a spectrographic analysis is run on those elements of most interest. It is then analyzed accurately for zinc, cadmium, and lead content as well as other elements whose presence is indicated to be in amounts of importance to the smelter.

The Palmerton plants use more than 400,000 tons of anthracite, bituminous coal, and coke per year. The grades of anthracite received range from rice size to fine dust on which a system of quality control is exercised by the fuels supervisor who may have single carloads analyzed or fairly large composites made up for analysis, depending on visual quality inspection or upon the record of continued good quality from some suppliers. Similar control is maintained over bituminous coal for the vertical retort plant and coke for the blast furnace. Coke quality is examined by ash analysis, abrasion and fracture tests.

The products inspection div. has the responsibility for sampling, testing, and grading pigments for physical properties as specified. Its gradings on materials in process assist the operating departments in furnace control and guide them in blending to make mixtures having all the desired properties. Gradings on samples of the packed pigments give assurance that the products meet the proper physical and chemical specifications.

Storing and Shipping

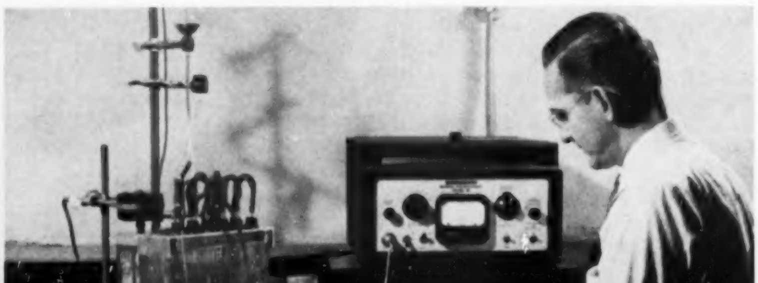
The responsibility for storing and shipping metal and pigments is a testing dept. function. Efficient storing and shipping practice begins with the casters of metal and with the packermen of bagged products.

The slab zinc casters form a 3000-lb unit of slabs in a shaper built on a Yale tin plate truck as the slabs are removed from the molds. The bottom slabs are molded to permit entry of lift truck forks. Three automatic storage battery trucks and two Towmotor gasoline engine driven trucks, all of 2-ton capacity, are in service.

Testing dept. is responsible for storing and shipping metal and pigments, such as this zinc oxide, in addition to sampling and testing duties.

Spiegeleisen is dropped from the casting machine to large tote boxes which are moved by 9-ton capacity Ross Carrier fork trucks.

The packerman piles bags of pigment in a shaper in a predetermined interlocking pattern. The unit of bags is removed from the shaper on the forks of a lift truck, and is moved to a hydraulic press where approximately 10 psi is applied. This pressure gives the unit the stability necessary for storing, loading and delivery to customer. Units are stored three high supported by strong cardboard separators. When the truck handles a unit for shipment an unloader device pushes the unit onto the floor of the railroad car or highway truck. If the customer is to unload by fork truck the units are placed on corrugated cardboard sheets which allow the customer's lift truck forks to readily pick up the unit for removal from the car or truck. A total of nine Yale and Towmotor gasoline engine driven trucks of from 1.7 to 2.7-ton capacity are in use for the handling of pigments and miscellaneous products. The latter are packed in pails, drums and cartons and are stored on pallets from which they are for the most part manually unloaded for shipment.



LEFT: Samples are taken from a carload of zinc concentrates by using the tube sampler at 12 locations. RIGHT: Polarograph technique permits determination in a matter of minutes of amount of lead and cadmium in sample of commercially pure zinc.

East end of Depue plant shows from left to right: Slab zinc change house; refinery and retort buildings; power house, shops, and supply house; and at extreme right the laboratory and main office.

DEPUE

Serving the Midwest and West since 1905

ABOUT the turn of the century rapid industrial expansion greatly increased Middle Western slab zinc requirements, and in 1905 the plant at Depue, Ill., was built to meet this demand. Site for the Mineral Point Zinc Div. was determined by proximity to Illinois coal fields, to Wisconsin, Illinois, and Tristate zinc mines, and by the good transportation facilities.

Primarily built to produce slab zinc and sulphuric acid, the original plant was the largest of its kind in the U. S. Since then sulphuric acid manufacture has been discontinued, a lithopone plant constructed, and vertical retort furnaces have replaced the original horizontal retorts. Depue currently produces Horse Head Special slab zinc, Zamak zinc alloys, metal powders, cadmium, and lithopone.

This article is focused upon production, engineering, and maintenance, but other departments and divisions whose proper functioning is essential to a well-rounded and integrated plant include: personnel, accounting, testing and laboratory, pyrometric, medical, and service and yard group.

Tapping cadmium furnace at Depue.

ABOVE: N. K. Banks, Superintendent of the Depue plant. LEFT: The staff of authors, left to right: C. W. Geppelt, Chief of Lithopone Dept.; C. D. Rudolf, Asst. Chief of Lithopone Dept.; P. A. Jensen, Chief of Slab Zinc Dept.; F. A. Olson, Chief of Engineering Dept.; A. T. Beckley, Asst. to Superintendent; and W. F. Boyer, General Foreman, Slab Zinc Dept.

Slab Zinc Production

by P. A. Jensen and W. F. Boyer

SLAB zinc smelting at Depue is very similar to operations at Palmerton, however, it has less over-all capacity and fewer products. Horse Head Special slab zinc is the principal product, and other products for midwest and western customers are Horse Head zinc, anodes, die casting alloys, and metallic zinc powder.

Concentrates normally smelted at Depue come mainly from company mines at Gilman, Colo., and Hanover, N. Mex. The concentrates are roasted either at Canon City, Colo., or are custom roasted in transit. Some roasted concentrate is sintered at Depue and the remainder at Canon City.

Most of the flash-roasted concentrates received at Depue are sintered on a standard Dwight-Lloyd downdraft machine. The machine has an effective area of 132 sq ft and the three wind boxes are handled by a 200-hp fan.

A rod-curtain, horizontal flow type Cottrell electrostatic precipitator was recently installed on the stack discharge of the sintering machine. Designed to handle 32,000 cfm of gas at 45,000 to 50,000 v, its operation has been satisfactory.

Sinter plant stack fume is collected in bins under the precipitating chambers and withdrawn from the bottom by an enclosed drag conveyor. Fume is calcined in a 3x14-ft externally fired rotary muffle. Calcining densifies the fume from about 20 to over 120 lb per cu ft. Carload lots are sold to other smelters for extraction of cadmium, lead, silver and gold values.

The mix house, formerly used by the long since abandoned horizontal retort plant, has been modified to prepare mixed charge for the vertical retort briquetting and coking operation. It is equipped with bin space for about 5000 tons of zinc materials and coal.

Mix preparation starts with the fine grinding of sintered roasted concentrates and bituminous coal, done separately in a Marcy rod mill. The ground materials are conveyed to bins to be incorporated in the mixed charge.

Charge preparation is similar in all essentials to that at the Palmerton plant.

The vertical retort plant at Depue consists of two 8-retort batteries. The major point of difference between Depue and Palmerton is that the Depue plant is fired with natural gas instead of producer gas. Another feature novel to Depue is the use of an automatic electrified monorail system to convey the ladles of molten metal to the refining furnaces in an adjacent building.

Depue has five refinery units each with two lead and one cadmium removal columns for production of Horse Head Special zinc. These units are similar to those in use at Palmerton except that they are fired with natural gas instead of producer gas. Most of the refined zinc is cast directly into 42-lb slabs. A small amount is converted into die casting alloys (Zamak 3 or 5), or metallic zinc powder. Dross and pot skimmings from these units are fed to the vertical retorts for zinc recovery. Byproducts containing cadmium go to the cadmium plant for treament.

Zamak zinc base die casting alloys are produced in a plant adjacent to a refinery unit. Molten Horse

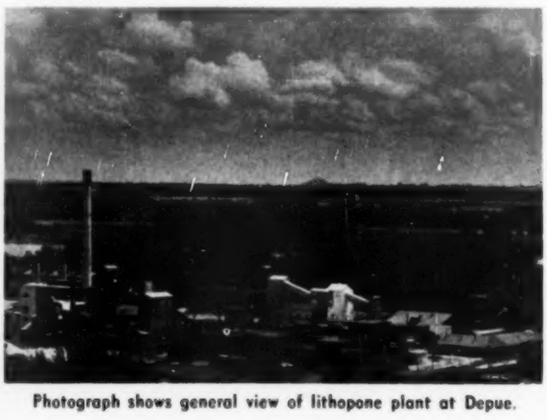
This Cleveland tramrail provides motorized, automatic transportation of molten zinc from vertical retorts to refineries.

Head Special zinc is taken directly from the refinery and alloyed with weighed amounts of either aluminum or an Al-Cu alloy and magnesium in two 3000-lb capacity cast iron pots. These batches are cast into 20-lb ingots and transferred on the narrow gauge railroad to storage for shipment.

Metallic zinc powder is made in an atomizing plant located near the refinery units. The zinc, melted in a 10-ton capacity reverberatory furnace, is poured in a thin stream into a high-pressure air jet. The atomized zinc is blown into a collecting chamber, from which the powder goes to shaker screens for sizing and packing in 100-lb steel drums.

All the merchantable products are moved by diesel locomotive on a narrow gauge railway to a storage and shipping center. As much as possible slabs and ingots are made into unit loads for efficient handling by two 2-ton capacity fork lift trucks.

The narrow gauge railway moves practically all of the raw and finished materials within the slab zinc dept. This includes slab zinc metal in its various forms, mixed furnace charge, furnace residues, brick shapes for furnace rebuilds, and miscellaneous items of machinery.



Photograph shows general view of lithopone plant at Depue.

Lithopone Production

by C. W. Geppelt and C. D. Rudolf

THE Depue lithopone plant, built in 1923 with an original capacity of 1800 tons per month, through the addition of improved equipment is now rated at 2250 tons per month. Lithopone is a white pigment having the chemical composition of $ZnS \cdot BaSO_4$, formed by co-precipitation from purified zinc sulphate and barium sulphide solutions. Pigment properties are developed by controlling the chemical composition of the solutions and the specific conditions of precipitation, calcination, and subsequent pebble milling.

Zinc Sulphate

Zinc sulphate liquor is produced from roasted ores and various types of byproduct materials containing zinc as oxide or metal. The zinc and other acid-soluble elements are dissolved in weak sulphuric acid using lead-lined rake agitated tanks. After decantation from the undissolved residues the liquor is aerated to convert the soluble ferrous iron to insoluble ferric iron. In this step a small amount of copper sulphate is added as a *promoter* and an excess of zinc oxide is used to neutralize the acid formed in the reaction. The copper is then precipitated by small additions of zinc dust and the slurry pumped to a thickener in which the *iron residue* is settled, removed as underflow, filtered and discarded. Manganese and final traces of iron are precipitated from the thickener overflow by oxidizing with carefully controlled amounts of potassium permanganate, and are removed by filtration. Cadmium and nickel are removed from the filtrate by cementation on zinc slabs, the resulting sponge being removed from the tanks at intervals for cadmium recovery. After final polishing in a filter press the zinc liquor, at 1.240 sp gr 60°C, is ready for precipitation. To improve the zinc recovery all residues are retreated before discarding.

Barium Sulphide

Barium sulphide liquor is produced by roasting barites (about 95 pct $BaSO_4$) under reducing conditions to a crude BaS (black ash), then water leaching. The roaster charge, 80 pct barites and 20 pct petroleum coke, is prepared by jaw and roll crushing, drying, proportioning, and fine grinding. The roasting is done in two 6x50-ft rotary kilns, natural gas fired. A bridge type crane is used for moving dry barites and coke from storage bins, and black ash to the leaching system.

Black ash is ground in a pebble mill with weak barium liquor, then pumped to a thickener where the solids are separated from the strong clear liquor. The thickener solids are countercurrent washed in four thickeners, the hot water used being condensate from the lithopone drying operations. The clarified barium liquor used for precipitation has 1.128 sp gr at 70°C.

Crude and Finished Lithopone

Barium and zinc liquors are brought together under carefully controlled conditions of flow, agitation rate, and acidity, batches of slurry being then end-pointed with small amounts of various reagents such as barium sulphide and sulphur. Precipitate is filtered in plate and frame presses, the cake being shoveled onto dryroom tray cars which are placed in drying tunnels, to be moved through them by a motor driven cog chain. Steam driven fans force the drying air through steam coils and over the wet pigment.

The dried cake is conveyed and elevated to be charged into 8-in. diam vertical steel calcining tubes 36 ft long, which are heated to about 900°C, outside temperature. Hot material is discharged continuously through water seals to quench tanks at a controlled rate.

The quenched pigment slurry is pumped for preliminary grinding to a group of five silex-lined mills loaded with Danish flint pebbles, and receives final grinding in colloid mills to a fineness of about 0.35 pct + 325 mesh. The pigment is blended in large tanks, dewatered in Sweetland pressure filters, and dried in the same manner as the initial precipitate filter cake.

The dried press cake is dry-milled in squirrel cage disintegrators, screened and packed in paper bags. The 50-lb bags are stacked in units weighing 1.2 to 1.5 tons which are handled by battery-powered fork lift trucks to a hydraulic press and thence to storage or shipment.

Average Over-All Recovery, Pct.

Zinc	87 to 90
Barium	77 to 79
SO_3	92 to 96

Cadmium Recovery

MAJOR sources of raw materials for cadmium metal production are byproducts recovered in zinc smelting and refining and in the lithopone operation. Refinery byproduct cadmium-zinc metal is melted and a vertical stream of the metal is dispersed by a jet of water to resolidify in metal flakes to promote a better solution rate when leached. This material, along with the lithopone process cadmium residues and other cadmium bearing materials, is leached in sulphuric acid. All tanks for cadmium wet processing are lead-lined with an additional protective layer of brick on the floor. Each tank has a finger type, wood agitator. All process lines are lead and a hard-rubber lined acidproof pump is used. Impurities are separated in a filter press using Orlon filter cloth and lead-covered plates and frames.

Cadmium is cemented out of the agitated solution by slowly adding a cadmium bearing byproduct zinc dust. The weakly acid zinc sulphate liquor drained from the resulting cadmium sponge is utilized in the lithopone operations. The sponge is water washed, removed from the tank floor and conveyed by monorail hoist to a 50-ton press to produce briquettes 4¾ in. diam and ½ in. thick.

The briquettes are charged to a distillation furnace, fired at about 1000°C, housing a clay-graphite bottle to which is attached a cast-iron condenser. Cadmium metal, distilled from the briquetted charge, is tapped at 2-hr intervals and rough cast. The rough cast cadmium is remelted in a cast-iron pot and finally molded into commercial sticks or ball anodes analyzing 99.9+ pct Cd.

Engineering & Construction Dept.

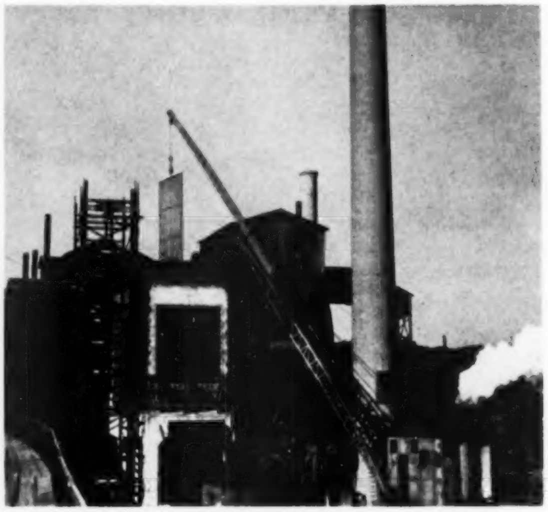
by F. A. Olson

THE Depue engineering and construction dept., comprising ten engineers and draftsmen, is responsible for activities of purchasing div. and the service and maintenance div. in addition to usual engineering functions. Since the end of World War II the department has been concerned with design and construction of new facilities, plant modernization, and major maintenance work.

Most field work has been carried on by the service and maintenance div. When advantageous or necessary, outside contractors are engaged, usually on specific phases of construction projects.

New facilities engineered and constructed by the department during the past 6 years included splash condensers on the 16 vertical retort slab zinc furnaces; facilities for the production of Zamak zinc base die casting alloy, zinc metal powder, and cadmium metal; increased capacity for the production of lithopone; and two installations for the recovery of sinter fume, one at Depue and one at Canon City, Colo.

A large amount of engineering and construction time was given to modernization of the steam, power, and water facilities, an undertaking which has been completed with no service interruptions. Old and inefficient boilers and steam driven air compressors have been scrapped. Engine driven dc generators have been replaced by purchased power delivered through a 3000-kva, 33,000-v substation to a 2300-v distribution system serving localized 440-v load centers. The relatively modern boiler plant serving the lithopone operation with process steam was enlarged by the addition of a dual fired, coal and natural gas, Babcock & Wilcox boiler of 30,000 lb per hr steaming capacity. This unit makes available ample steam for heating and processes in other parts of the plant, distribution being made through a new 800 ft long underground steam main. A 200-gpm boiler feed water treatment plant was included in the addition.



Typical tasks of the Depue engineering dept. include jobs like this installation of rod curtains in the sinter fume electrostatic precipitator.

Depue plant foremen include, left to right: (seated) E. R. Edwards, Foreman, Machine Shop; R. E. Moran, Foreman, Service and Yard; J. P. Helmer, Foreman, Construction; E. T. Walk, General Foreman, Service and Maintenance; (standing) L. Reinsch, Foreman, Riggers; F. Robeck, Foreman, Power; J. Wosik, Foreman, Pipefitters; A. Sautel, Foreman, Carpenters.

Numerous materials handling projects have been completed, improving plant efficiency and working conditions, and reducing labor costs.

The purchasing div., comprising four buyers and clerical help, handles orders for plant supplies, materials, and equipment, and for most of the materials for construction. Service and maintenance div. personnel number approximately 210, comprising a variety of crafts, including steel fabricators, steel erectors, riggers, masonry workers, repairmen, and painters.

New equipment has been installed and latest methods inaugurated in the machine, pipe, structural, electrical, and carpenter shops. Where old equipment has been retained, it has been rebuilt and individually motorized.

The Scintillation Counter in the Search for Oil

by R. W. Pringle, K. I. Roulston, G. W. Brownell, and H. T. F. Lundberg

The rapid improvement of the airborne scintillometer and the perfection of its efficiency for counting low energy gamma radiation has made it possible to work out a technique to map in great detail the radiation pattern at the earth's surface. On such maps low radiation over certain areas appears to indicate the existence of oil accumulations, forming a pattern similar to that obtained by the geochemists.

RADIOACTIVE analyses of samples from the surface of oil fields were carried out more than 10 years ago in Alberta by the alpha particle ionization chamber technique,[1] but large enough tracts could not be covered in these investigations to make possible any evaluation of the method as a means of oil exploration. Considerable interest has recently been revived, however, as a result of certain striking advances which have been made in the instrumentation available for the measurement of radioactivity. It is the object of this paper to indicate the nature of these improvements in radiation technology and then to describe the attempts that have been made to interpret the radioactive patterns obtained in the course of airborne recordings with the new instruments. Since the survey can be carried out from the air and records can be accumulated over vast areas in a short time, the result may easily lend itself to statistical treatment. Areas have been surveyed in Alberta, British Columbia, Saskatchewan, Quebec, Texas, New Mexico, Nebraska, Colorado, Utah, and Montana. Producing fields in Alberta and West Texas have been flown over several times in different directions, Fig. 1. The operations were then extended into unknown territory and drill holes were put down on the anomalies which looked promising. The results from these drillings were encouraging and have given hopes for the development of an entirely new method of oil exploration.

Any large scale method for the survey of radioactive anomalies must be based on the measurement of gamma rays, as beta and alpha rays have much too short a range to be of any significance. Thus the essential improvement which has made the present stage of this work attainable is the development of new highly sensitive detectors for gamma radiation. In the past the only detectors of any consequence that were available were the ionization chamber and the geiger counter, but both of these suffer from the defect that only a small proportion of the gamma rays passing through the counter are detected, possibly 0.1 to 0.2 pct. The recent development of the scintillation counter[2, 3] has completely transformed the situation and has had a considerable impact on many branches of nuclear technology.

The detection of alpha particles in zinc sulphide screens by visual observation of the individual scintillations which these particles produce dates back to the early spinthariscope of Rutherford and Crookes, but the combined use of an appropriate scintillating *phosphor* and photomultiplier tube had to await the technical development of the latter many years later. With this development came the modern era of the scintillation counter and a knowledge of phosphors which have a large light output under the bombarding action of gamma radiation. Some of these phosphors are relatively dense and are capable of stopping a large proportion of the incident gamma radiation. As the sensitive region is the whole volume of the crystal, a very high detection efficiency, 50 pct or more, can be obtained for medium energy gamma rays.

Scintillation counters for geological purposes were first developed in 1949[4-6] in an attempt to utilize this remarkable improvement in efficiency, which has the attractive consequence that only a small portion of the normal *background* of the counter is due to cosmic radiation. In 1949 tests were made in northern Saskatchewan by Lundberg Explorations Ltd. with portable scintillation counters which gave excellent results in the search for uranium and served to indicate unknown uranium deposits in areas previously closely surveyed with geiger counters. Portable *scintillometers* (registered in Canada) are now commercially available and in regular use,[7] and the adaptation of the instrument to radioactivity oil well logging has also been very successful.[8] Initial attempts to measure radioactivity from aircraft with scintillation counters were made during this period in the same area and yielded most encouraging results. It would be appropriate to consider some specific requirements for airborne investigations.

The essential problem to be met in the detection of any radioactive source is the necessity of obtaining a signal greater than the statistical fluctuations of the background counting rate for the instrument. It is possible to show that $Nt>2k^2$ is the condition for detectability of a signal where

N = average background counting rate for the detection.

t = time constant of the counting rate meter, used to determine the average number of counts arriving in a certain predetermined time interval.

N' = average source counting rate at the detector.

k = N/N', and $N>>N'$.

Sample values are given in Table I.

Assume that the aircraft carrying the equipment is travelling at 120 mph, in which case it will cover 176 ft in 1 sec. Assume also, as a first approximation, that a point source target is in range when the air-

R. W. PRINGLE and K. I. ROULSTON are Professors of Physics and G. W. BROWNELL Professor of Geology at the University of Manitoba, Winnipeg, Manitoba. H. T. F. LUNDBERG is President, Lundberg Explorations Ltd., Toronto.

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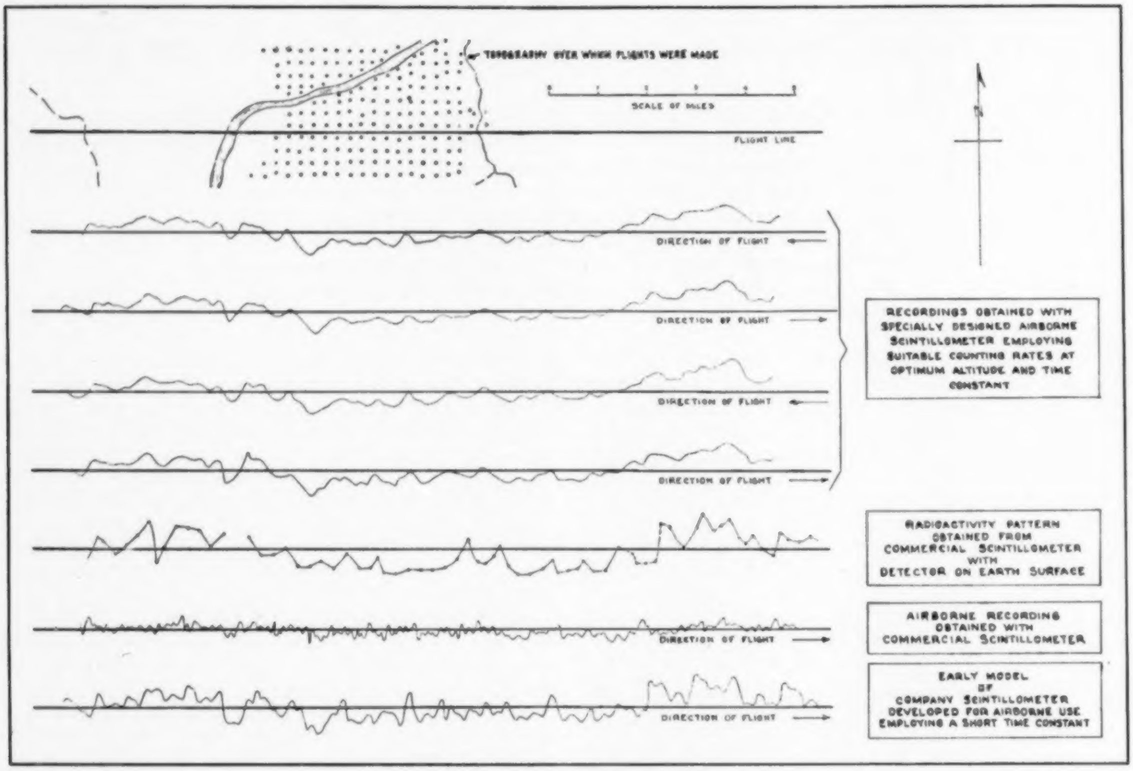

Fig. 1—Flight line repetition examples.

craft is within about 500 ft of the source. Beyond this, radiation is slight, owing to combined effects of atmospheric absorption and the inverse square law for radiation. This corresponds to 400 ft on each side of the source in a horizontal direction if the aircraft height is 300 ft, or 3.5 sec of flight time. To insure that scintillometer response may be sufficiently rapid to give a true indication of the anomaly it is evident that time constants not longer than 1 sec must be used. Thus values are obtained for N as given in the last column of Table I. These extremely high rates for the ordinary gamma ray background in an average locality can be achieved by 1—using large detecting crystals, 2—using several crystals and adding the counts from each one,

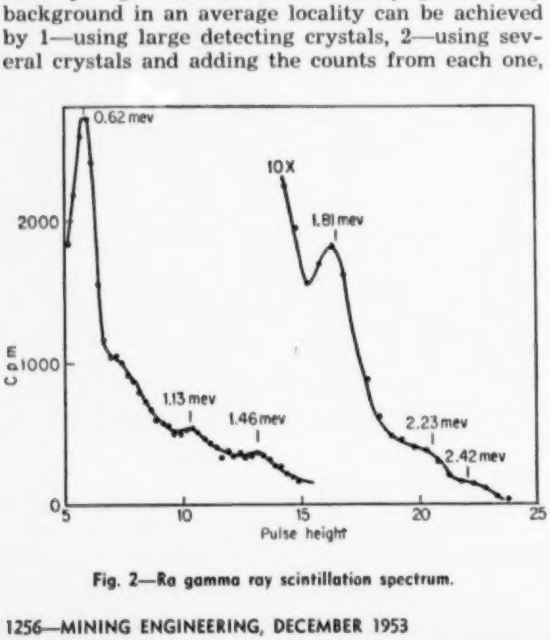

Fig. 2—Ra gamma ray scintillation spectrum.

3—using special low noise multipliers to enable more of the smaller pulses to be counted.

In addition the situation can be somewhat improved by the introduction of gamma ray shielding to reduce the background counting rate without materially affecting the signal from the ground. This shielding will also minimize the effects of gamma radiation from radon in the atmosphere and

Table I. Sample Values for a Radioactive Source Detected by the Scintillometer

Signal Just Detectable, Measured as Percentage Increase Over Background	k	Nt	Value of N, Counts Per Second for t of 1 Sec
2	50	5000	5000
5	20	800	800
10	10	200	200
20	5	50	50

from unwanted areas on the ground. It might be noted at this point that whereas the radon contribution to the average total ionization, including alpha, beta, and gamma rays, at 300 ft in the atmosphere, might be quite considerable in certain localities, *the scintillation counter as used here is measuring only effects due to gamma radiation*, so the influence of atmospheric radon is much smaller than it might appear at first sight.

It is possible to translate the above figures in terms of the practical results achieved. It has been shown that it is possible to regard a radiation intensity of 5×10^{-11} rontgens per sec as just detectable in the average locality, *with a time constant of 1 sec*. This amount of radiation corresponds roughly to the gamma radiation from 1 mg of radium, or 25 lb of

uranium ore assumed at 30 pct U_3O_8 at a distance of 200 ft. A much less sensitive detector might achieve the same result but would require a correspondingly longer integrating time and therefore be of no practical value in aerial survey work. The importance to be placed in the accurate delineation of very small percentage anomalies from the air will be indicated below, but before any discussion of the nature and origin of these very small signals it is opportune to mention another property of the scintillation counter that is of great significance in this problem.

The scintillation counter has the desirable property of acting as a proportional device, so that in essence it is a gamma ray spectrometer[9-11] in which a measure of the energies of the gamma rays is obtained from the pulse height distribution of the voltage pulses from the photomultiplier. The assumption is made, of course, that there exists a strict proportionality between the total light output per scintillation in the phosphor and the energy imparted by the gamma ray to the crystal, an assumption that has now been amply verified. The interaction between the gamma ray and the crystal may take place according to three processes well known to the nuclear physicist: the photoelectric effect, the Compton effect, and the pair production effect. The end result of this is that it is therefore possible to identify in the voltage pulse height distribution curve for a given gamma ray energy, either a photoelectron *line*, or a pair production line, or a distribution corresponding to the Compton effect, or a combination of these. Fig. 2 shows the pulse-height distribution obtained with the gamma rays from radium using a NaI (T1) crystal, and Fig. 3 is for the gamma rays of thorium. Considerable attention has been given to the development of methods for the rapid analysis of distributions of this type, using single channel *differential* discriminators, multi-channel kicksorters, and photographic storage methods employing a cathode ray tube. The latter group of techniques is the most suitable for field use. The value of this proportional property of the scintillometer in geographical investigations lies in the ability of the device to identify a particular anomaly in terms of the spectrum, as well as the intensity of the gamma radiation involved, and thus indicate the nature of the radioactive atoms responsible. It might be noted that the gamma radiation from potassium consists of a single line at 1.47 mev. Fig. 4 gives the dependence on energy of the spectrometer resolution R, defined as the full width of a line at half height.

Oil Field Surveys

To obtain the radioactive data over an oil field, continuous gamma ray recordings are made along flight lines flown over large areas following a predetermined pattern. The flight altitude may vary between 150 and 500 ft above the ground. The speed of the aircraft is not important, although 100 to 150 miles per hr has been found to be very satisfactory. The records obtained are processed and adjusted as to linear scale and then plotted directly along the flight lines on the maps. The results of flights over known oil fields and areas of different types of topography and drainage pattern indicate clearly that great care must be taken in making the interpretation. It is found, however, that radioactive *lows* generally are obtained over oil fields and that these *lows* are commonly surrounded by radioactivity slightly higher than normal. The variations in intensity may look erratic over broken topography,

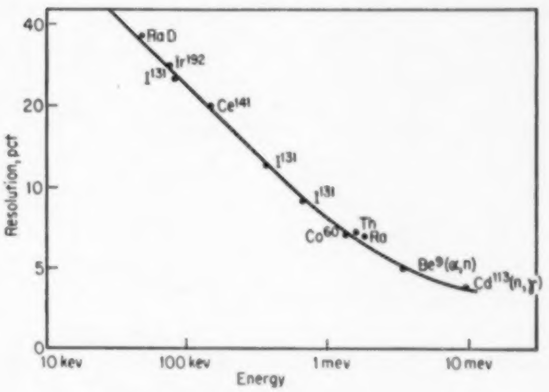

Fig. 3—Th gamma ray scintillation spectrum.

lakes, swamps, and river valleys, but as a rule lows above the oil fields can still be observed. In areas where radioactive shales occur near the surface high intensities may be noted. Lakes, rivers, and sometimes areas of swampy land show marked lows.

On Figs. 5 and 6 are shown radiation profiles along flight lines 1 mile apart over Redwater oil field in Alberta. East-west lines are shown on Fig. 5 and north-south lines on Fig. 6 of the same area. Fig. 7 shows radiation profiles along east-west flight lines ½ mile apart over Coalinga oil field in California.

An arbitrary datum of 150 counts per sec has been used. Radiation intensity higher than normal is shown above the datum line, while lower intensity falls below the datum.

The masking effect of surface water in swamps and rivers may be noted but, in spite of this, most of the area now known as oil producing shows low intensity.

Radioactivity surveys, as made with an airborne scintillation counter, contribute information that is most effectively employed in conjunction with other types of geophysical data. Consider a large tract of territory covered by airborne electric or magnetic surveys or by ground seismic surveys within which several anomalies indicative of structural highs occur. Should the radioactivity survey with its variable pattern over this same area show a radioactive low coinciding with one of the magnetometer anomalies, the probability of an oil pool at this particular site is greatly strengthened. As for every decision to drill, all data must first be assembled, and the radioactivity survey is a contribution to this material.

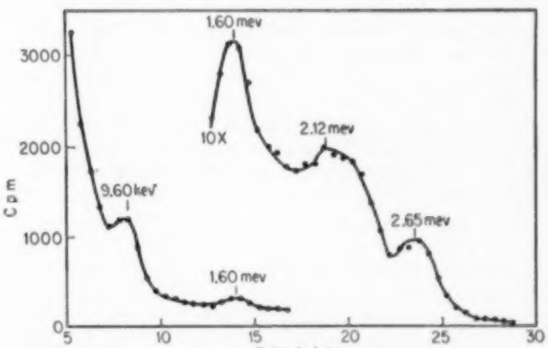

Fig. 4—Resolution energy relationship.

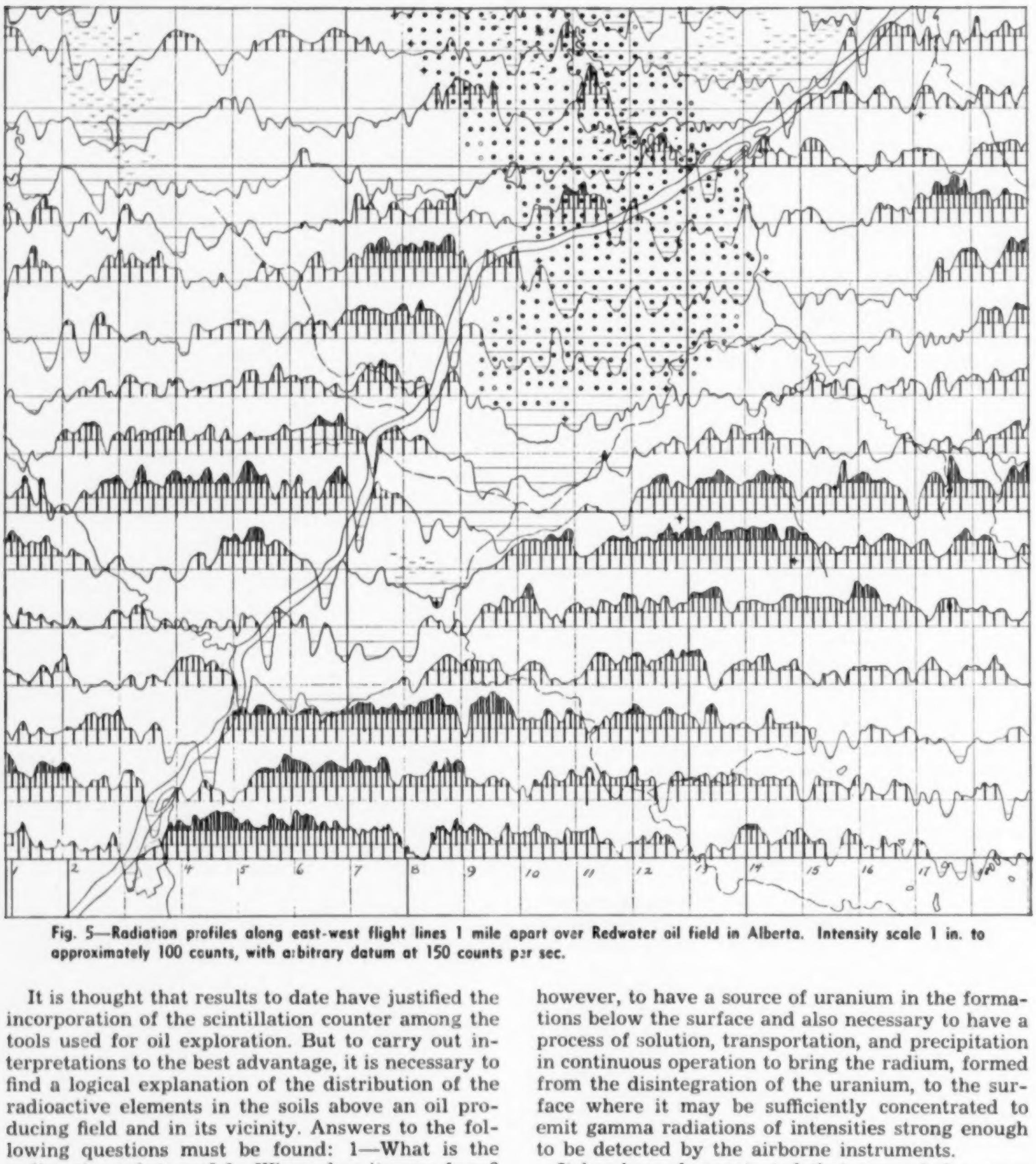

Fig. 5—Radiation profiles along east-west flight lines 1 mile apart over Redwater oil field in Alberta. Intensity scale 1 in. to approximately 100 counts, with arbitrary datum at 150 counts per sec.

It is thought that results to date have justified the incorporation of the scintillation counter among the tools used for oil exploration. But to carry out interpretations to the best advantage, it is necessary to find a logical explanation of the distribution of the radioactive elements in the soils above an oil producing field and in its vicinity. Answers to the following questions must be found: 1—What is the radioactive substance? 2—Where does it come from? 3—How does it get to the surface? 4—What is the explanation of the low radioactivity over oil fields and the increase over the edges?

The uranium-radium disintegration series must be considered before the first question can be answered. Radium is constantly being formed from uranium, and its salts have a water solubility suggesting that the radium stage of the series is the more important in the upward transportation of the radioactive materials. The gamma radiation detected in the surveys comes mostly from the daughter products of radium, of which RaC is the most important. Because of the very short lift of RaC, the supply of this isotope must be continually renewed. Since the half-life of radium is 1600 years, it would not be necessary to have uranium itself transported to the surface layers. It is necessary, however, to have a source of uranium in the formations below the surface and also necessary to have a process of solution, transportation, and precipitation in continuous operation to bring the radium, formed from the disintegration of the uranium, to the surface where it may be sufficiently concentrated to emit gamma radiations of intensities strong enough to be detected by the airborne instruments.

It has been demonstrated that some shales carry an appreciable amount of uranium. Many years ago Russian scientists inspired by Nordenskiold's discovery in 1893 of a high uranium content in some Swedish oil shales, found that oil field waters could be high in radium and that this radium could be precipitated by adding sulphates to the water. In fact a small quantity of radium was produced in this way at Uhta Oil Field in north Russia. Uranium apparently is present in any major marine sedimentary column, especially in the shales. But it remains to find out how the radium is brought so close to the surface.

Before the second, third, and fourth questions are answered, a study should be made of some of the few geochemical maps and results that have been published. It appears from the maps that hydrocarbons reach the surface by leakage from the oil

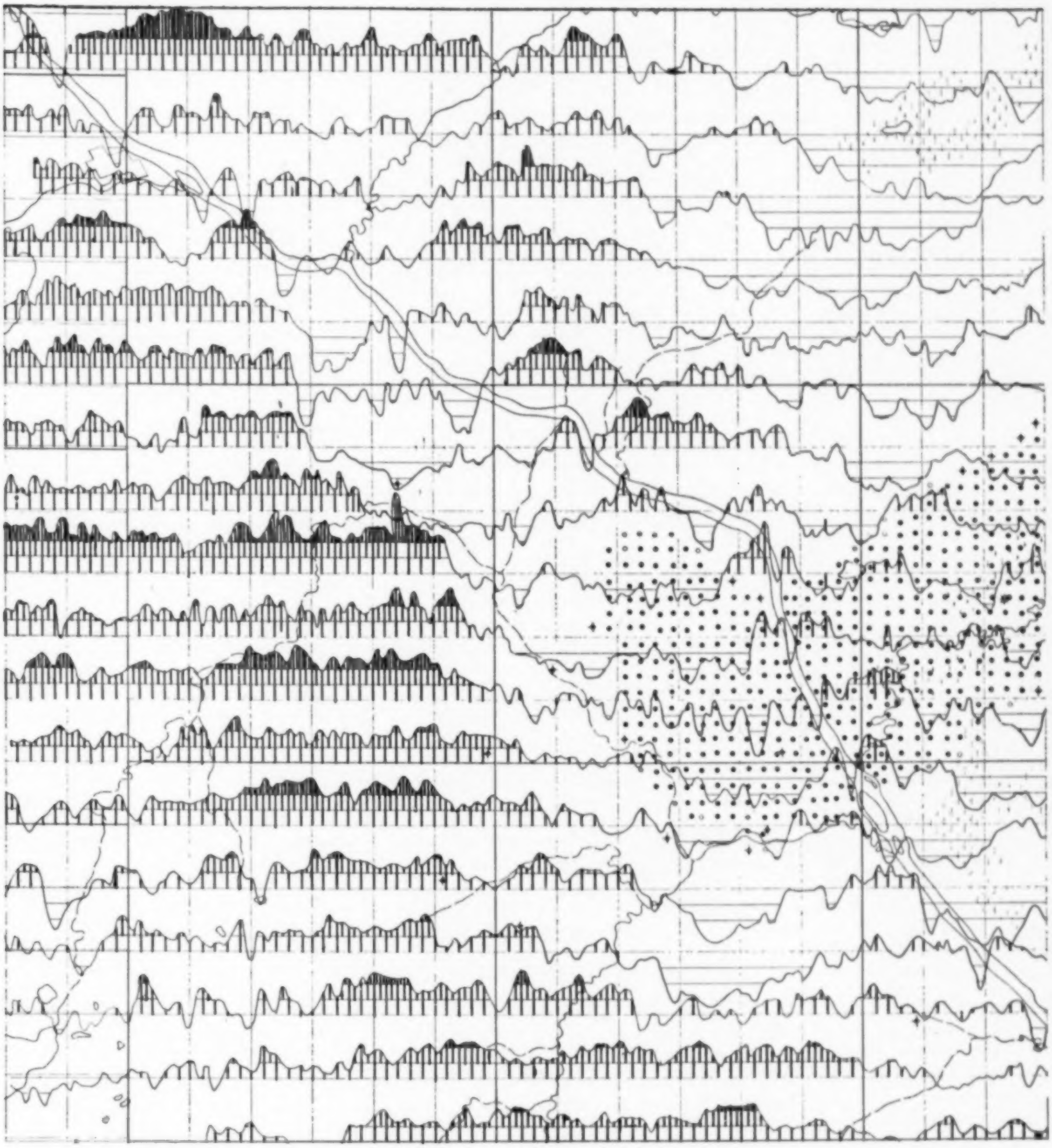

Fig. 6—Radiation profiles along north-south flight lines 1 mile apart over Redwater oil field in Alberta. Intensity scale 1 in. to approximately 100 counts, with arbitrary datum at 150 counts per sec.

deposit. The maps often show a hydrocarbon concentration as a ring or halo around the oil field, sometimes also accompanied by a concentration of chloride. This would mean that beds, against which the hydrocarbons are accumulating, never become completely impermeable until the oil has replaced the water. It also shows that salt water, as well as the hydrocarbons, can travel upwards more or less vertically to the surface. If an oil accumulation is in the way of the upward-trending salt water, it is forced to take the way around the edges of the oil, which means that the speed of the current around the edges is increased. Over the oil pool, on the other hand, the flow should be very slow. This may explain the ring or halo of high hyrdocarbon or chloride concentration observed at the surface, as well as the minimum right above it. However, in this connection opinions are still at variance.[10]

The conditions described would favor the forming of similar anomalies in the radioactive radiation from the surface. If hydrocarbons and salt water move together towards the surface, any sulphate contained in the water is reduced to sulphide by the hydrocarbons present. Such a reduction of the sulphate in the surface waters will also take place if minute oil drops or gas bubbles should find their way to the surface. Since the atmospheric ground waters are rich in oxygen, they generally also contain sulphate. A reduction will also take place if the atmospheric waters mix with waters from below carrying some dissolved oil. It can be shown that hydrocarbons are capable of reducing a great deal of sulphate. Even a small amount of oil that may be dissolved in water (approximately 0.02 pct) is sufficient to reduce completely a saturated solution of

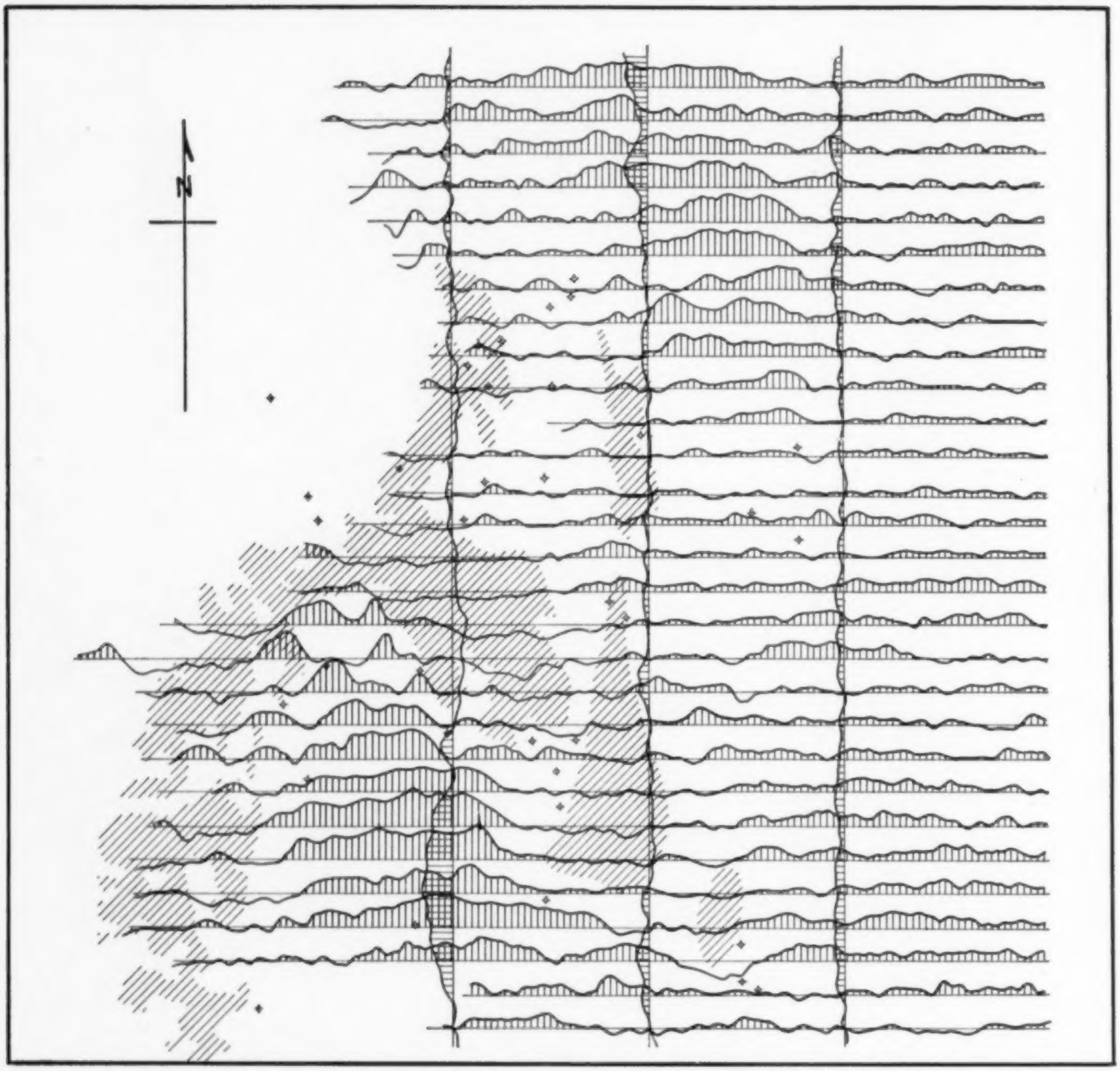

Fig. 7—Radiation profiles along east-west flight lines ½ mile apart over Coalinga oil field in California. Recordings obtained with specially designed airborne scintillometer employing optimum counting rate at optimum altitude and time constant. Horizontal scale 1 in. to the mile. Intensity scale approximately 200 counts per sec.

calcium sulphate. Ordinarily the ground water content is much lower.

Sulphate-free waters may dissolve radium as it is formed from uranium in the rocks, and this would explain the sometimes exceptionally high radium content carried in water from below. Even if the uranium content in these waters is high, as compared with other waters or the oil, this uranium content is very low compared with the uranium content in the ground. It must, therefore, be assumed that the radium content in the sulphate-free waters originates from leaching of uranium minerals and not from any original uranium content in the water or in the oil.

This would mean that a minute leakage of hydrocarbons, sufficient to reduce all sulphate in the ground water to sulphide, would increase the radioactivity of the water considerably without the waters having been in contact with rocks especially high in uranium, such as the black shales which are sometimes assumed to be the origin of the oil.

It is rather unlikely in fact that radium which originates from deep-seated, uranium-bearing rocks or formations close to the oil deposits is the cause of the radioactive anomalies at the surface, since the bulk of the radioactive substance which may be transported to the surface from such great depths would disintegrate and lose its radioactivity on the way up. Even with as fast a movement of the water as 1 in. per year, less than 2 pct of the original radioactivity would remain after rising 800 ft. Therefore the anomalies in the radiation, which have been observed over oil fields, could not be caused by any upward transportation to the surface of radioactive substances from the deep-seated levels of the oil concentrations. If any relation exists, it probably would be found in the fact that the hydrocarbon leakage to the surface has given to the waters at relatively shallow depths the power to dissolve radium from the surrounding rocks. This water, being on its way upward, presses towards the surface with varying velocity, the greatest velocity

being at or near the edges of the oil deposit. This is in agreement with what the geochemists claim to have found, namely, that a hydrocarbon leakage exists together with the transportation of relatively chloride-rich waters towards the surface near the edges of an oil deposit. Even the most penetrating radioactive radiation is stopped by a few feet of rock or soil. Therefore, the radioactive substance must be transported to the surface so that the radiation may be observed from a plane. This transportation of radium to the very surface might be objected to, since on approaching the surface the upward moving waters would encounter air, and the oxygen would then turn the sulphides to sulphates. It is known, however, that in the presence of organic matter, the free oxygen and even the sulphates may disappear at surprisingly shallow depths. In salt marshes the anaerobic activities are known to begin less than 1 in. below the surface.

An investigation of ground waters was made for a period of several years in Sweden at the Lanna Experimental Farm,[13] where certain very important data were gathered. During the winter the sulphate content was at its maximum, 28.8 ppm, but this content diminished during the summer and the water during the late summer became free of sulphate. At the same time the concentration of dissolved solids reached a maximum which indicated evaporation and upward movement of the ground water even close to the very surface. The ground water movement was reversed to downward in the fall and winter, and then the sulphate content reappeared. The amount of organic matter consumed to reduce the sulphates corresponded to only 1/40 of the quantity of oil that may be dissolved in water, or to a daily leakage per square meter of 2 mg of oil or 2 cu cm of methane, i.e., 1 gal of oil or 100 cu ft of methane per acre per year. From this it becomes apparent that even a microscopic hydrocarbon leakage from an oil or gas deposit could make the ground water, at least sometime during the year, free of sulphate all the way to the surface. If then, as at Lanna, the water moves upwards through evaporation, any dissolved radium would be transported to the surface. The change takes place and the superficial ground water receives oxygen and at the same time begins to move downwards. The radium previously transported up will not necessarily again follow the ground water downwards. On the contrary, it is more likely that most of the radium is precipitated in the ground as sulphate, will remain near the surface, and when the sulphates again disappear will get another lift towards the surface.

It has been assumed that radiation from the ground, as observed and recorded from aircraft, must come mainly from Radium C, which is a product of radium and radon. Radon is a gas and can move closer to the surface than radium and naturally diffuses into the free air. Therefore, it would seem as if there would be a good chance, in the vicinity of oil or gas deposits, for a natural transport of radioactive substances to the surface of the ground so that its radiation could be measured and recorded from a plane if it does not fly too high. Tests across Redwater field, Alberta, in August 1951, verified this point. Soil samples were taken at depths of 1, 3, and 5 ft from a series of test holes across the field. Gamma counts were also taken on the surface of the ground at each location. The gamma counts on the soil samples as plotted against geographical position corresponded not only to the surface count, but also to the continuous airborne recordings.

A gamma ray spectrum analysis as described in the previous section was performed on the soil samples. Those from the oil field perimeter, where the counting rate was high, gave evidence for the presence of Ra and its decay products, whereas in the regions of low counting rate over the oil field the spectrum appeared to be largely potassium, k^{40}.

The radiation is obstructed by the water in lakes and rivers. Marshes and swamps may also blot out the radiation. However, in some cases, a vertical transport of radioactive substances through the peat, but naturally not through moveable water, seems to take place, so that it is possible to obtain variations from the bottom of the peat layers, peat being a strong reducing agent. However, it is necessary to make corrections for the lowered radiation intensity before any anomalies can be compared with those over drier soil.

It may be held as an objection to this theory that shallow waters containing oxygen and sulphate and having a downward and lateral movement should prevent the forming of any geochemical anomalies at the surface that could have any relation to the underlying, deep-seated oil or gas deposits. Such conditions may not be uncommon, but are they so frequently prevailing that the method becomes unworkable? In this connection it is necessary to bear in mind that a very great portion of the earth's oil and gas resources have been found by drilling near oil or gas seepages which could have been noticed by anyone. It is probable that there must exist a great many more deposits that only reveal their presence by gas or oil traces which are difficult to detect at surface. It may be mentioned here that in some cases radiation *highs* were noted over certain fields in production, particularly over older fields in Texas. This may be explained from the fact that in some oil fields, where in the beginning no one was particular regarding the disposal of brines, such areas could have been radioactively contaminated. The value of the radioactive prospecting method can be determined only after a sufficient number of newly found anomalies have been drilled and a percentage of successes can be compared with that of already existing methods.

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The Coal Industry in Northern Wyoming and the State of Montana

by Walter J. Johnson

The coals in northern Wyoming and Montana are free-burning and non-caking and range from lignite to bituminous C in rank. Strip and underground mining are employed to supply railroad, utility, industrial, and domestic fuel. The market area includes Iowa, Nebraska, Minnesota, North and South Dakotas, Wyoming, Montana, the Pacific Northwest, and western Canada.

THE larger producing coal mines in northern Wyoming are located in the Powder River Basin lying between the Black Hills region of South Dakota, eastern Wyoming, and the Big Horn Mountains in north central Wyoming, see Fig. 1. The mines are located particularly in the area along the route of the Chicago, Burlington & Quincy Railroad from Gillette, Wyo., to a point approximately 15 miles northeast of Sheridan, Wyo. Fig. 2 is a graph of coal production in the state of Wyoming from 1918 to 1951.

Across the Big Horn Mountains lies the Big Horn Basin, situated between the Big Horn Mountains and the Rocky Mountains proper. Mining in the Big Horn Basin is almost entirely confined to a small area known as the Gebo Field, near the town of Kirby, which is located on the Chicago, Burlington & Quincy Railroad.

This paper will describe present operating areas, making only brief reference to the history of mining and marketing primarily because of the large area to be discussed.

The coal beds presently mined in the Powder River Basin are all of Tertiary age and are of Fort Union and Wasatch formations of Paleocene and Eocene ages, see Fig. 3. The Fort Union formation, consisting of 2000 to 3200 ft of alternate sandstone, shale, and coal, is divided from oldest to youngest into the Tullock, Lebo Shale, and Tongue River members. Most of the mineable coal is in the Tongue River member, which is 500 to 800 ft thick.

The Carney coal bed, varying from 7 to 20 ft in thickness, is considered the base of the Tongue River member. About 85 ft above the Carney is the Monarch bed, ranging from 18 to 42 ft in thickness. At approximately 210 ft above the Monarch is what is locally known in the Sheridan district as Dietz No. 3 bed, which varies from 12 to 30 ft in thickness. One hundred feet above the Dietz No. 3 is Dietz No. 2 bed, which is 7 to 12 ft thick. At about 100 ft above the Dietz No. 2 is Dietz No. 1 bed, 7 to 15 feet in thickness. Two hundred and fifteen feet above Dietz No. 1 is the Smith bed, approximately 5 ft thick. One hundred twenty-five feet above the Smith is the Roland bed, which is estimated to be approximately 13 ft thick. The Roland bed is considered the base of the Wasatch formation, which in the Powder River Basin is 1000 to 3500 ft thick and is composed largely of shale, sandstone, and coal.

The foregoing measures are the only ones above the Tongue River member that have been mined in the Sheridan field. To the east of the Sheridan field, particularly in the area of Gillette, the Roland bed is considerably thicker and is considered the thickest and most extensive coal bed in Wyoming, reaching a maximum thickness of 106 ft.

From 125 to 225 ft above the Roland lies the Arvada bed, average thickness 9 ft. Three hundred seventy-five to four hundred feet above the Arvada is the Felix bed, which reaches its maximum thickness of 30 ft near Echeta on the Chicago, Burlington & Quincy Railroad. East of the Powder River the bed averages more than 10 ft in thickness, but it thins in a northwesterly direction.

The highest mineable coal in the Powder River field is the Healy bed, about 400 ft above the Felix bed and exposed only in the highest parts of the area where much of it has been burned along the outcrop. Where it has not been burned, the thickness at most of the outcrops is 10 to 15 ft.

W. J. JOHNSON, Member AIME, is President of Sheridan-Wyoming Coal Co., Inc., Monarch, Wyo.

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The foregoing comprise the major coal beds above the Tongue River member; however, there are a number of intermittent and upper beds not being mined at the present writing.

Below the Tongue River member and in the Sheridan field lying 60 ft below the Carney bed is Masters No. 1 bed, 6 to 16 ft thick; 60 feet below the Masters No. 1 bed is the Masters No. 2 bed, which is approximately 12 ft thick.

The coal throughout the Powder River region is classed as subbituminous C and B rank, as determined according to the standard specifications of the American Society for Testing Materials, see Table I. A small area in the northeastern part of the Powder River Basin is believed to contain lignite and is very near in rank to subbituminous C coal. In earlier years, higher quality coal in the Black Hills region, known as the Cambria field, was mined and coked to some extent. This field, however, is foreign to the Powder River Basin in that it is of lower Cretaceous age. Most of the coal in the Cambria field is of high volatile C bituminous rank. Coal from certain parts of the bed has coking qualities and has been used in the past for manufacturing coke for smelters in the Black Hills region. The mines in the Cambria field have been closed for a number of years, and most of the better quality and more acceptable coal has been mined out. There is no other known coking coal in northern Wyoming. There is possibility of coking coal lying at great depths in beds that have not to date been explored.

Mining Operations, Powder River Basin, Wyoming

Present mining operations in the Powder River Basin are confined to the Wyodak Coal Co., operating about 6 miles east of Gillette; the Sheridan-Wyoming Coal Co., Inc., operating 12 miles northwest of Sheridan; and the Big Horn Coal Co., operating approximately 14 miles northwest of Sheridan. These companies are the only rail shippers now in the Powder River Basin. They are served by the Chicago, Burlington & Quincy Railroad.

In addition to the foregoing are the following truck mines in Sheridan County: the Custer Coal Co., the Storm King Coal Co., the Black Diamond Coal Co., and the Welch Coal Co. There are numerous so-called *country-bank* mines in the Powder River Basin operating on a very small scale.

There are numerous locations of readily available coal from the various beds throughout the entire area. It is only the lack of available market that prohibits exploitation on a larger scale. In the early days of mining in the Powder River region the coal was used primarily for railroad fuel and domestic

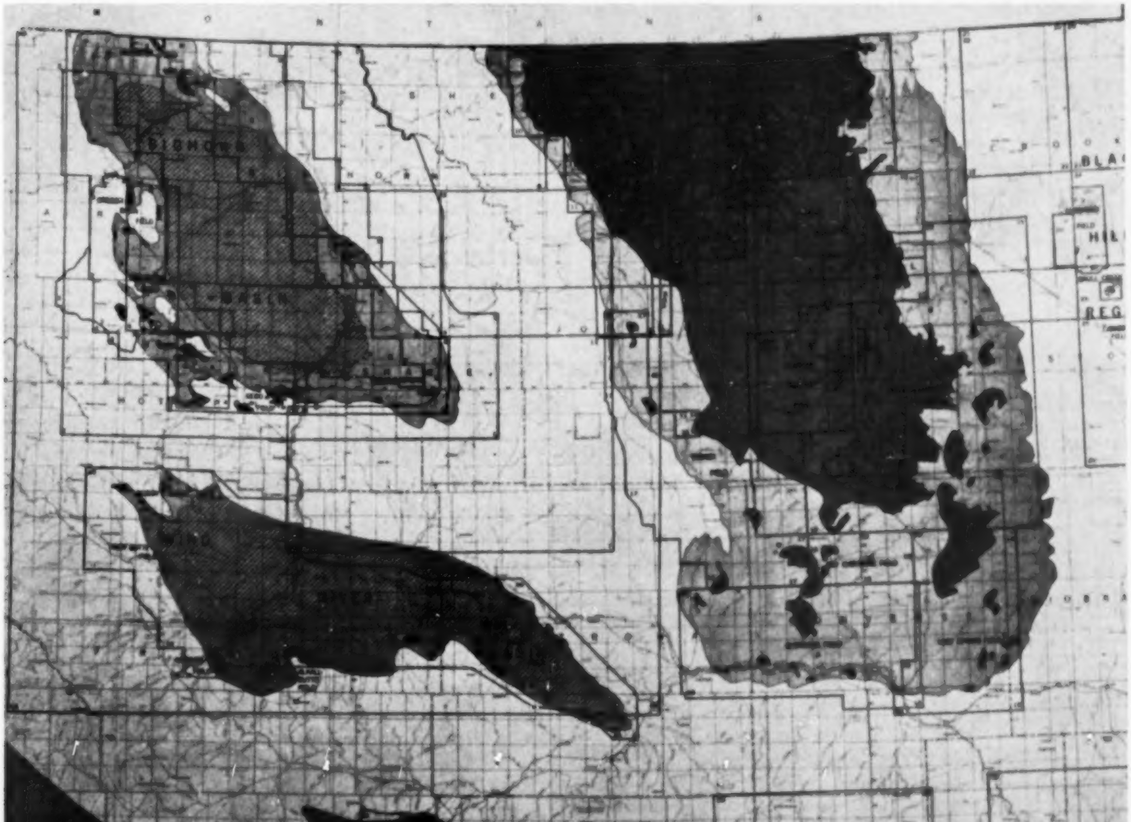

Fig. 1—Location of the larger producing coal areas of northern Wyoming. Heavy shading indicates subbituminous coal areas containing beds more than 30 in. thick. Light and intermediate shading indicates subbituminous areas containing beds less than 30 in. thick or of unknown thickness. Intermediate shading also indicates coal-bearing formations less than 30 in. thick.

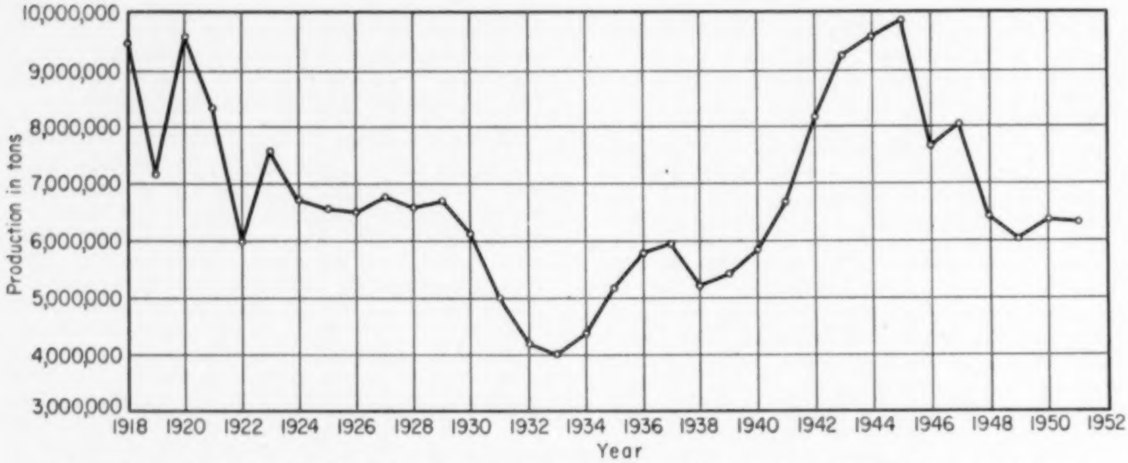

Fig. 2—Coal production in the state of Wyoming from 1918 to 1951. Source of information is the annual report of the State Inspector of Coal Mines of Wyoming, 1951.[1]

consumption by local ranch and farm owners and was sent to the very sparsely settled communities.

Table I. Data from *Classification of Coals by Rank*. Determined According to the Standard Specifications of the American Society for Testing Materials as Applicable to Subbituminous and Lignite Coals.

Class	Group	Limits of Fixed Carbon or Btu Mineral-Matter-Free Basis	Requisite Physical Properties
Subbituminous	Subbituminous A coal	Moist Btu, 11,000 or more and less than 13,000*	Both weathering and nonagglomerating
	Subbituminous B coal	Moist Btu, 9500 or more and less than 11,000*	
	Subbituminous C coal	Moist Btu, 8300 or more and less than 9500*	
Lignite	Lignite	Moist Btu, less than 8300	Consolidated
	Brown coal	Moist Btu, less than 8300	Unconsolidated

* Coals having 69 pct or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of Btu.

The most easterly operation is the Wyodak strip mine, believed to be the Roland and Smith beds which have merged to form an aggregate thickness of about 90 ft with only an 8-in. parting separating the two beds. The analysis of this coal, according to the U. S. Bureau of Mines, is as follows:

Moisture, pct	31.8
Volatile matter, pct	30.1
Fixed carbon, pct	31.6
Ash, pct	6.5
Btu as rec'd	7,840
Sulphur, pct	0.6

The coal is marketed industrially to cement plants, power plants, and to the Chicago, Burlington & Quincy Railroad for engine fuel, and domestically in the vicinity of Gillette, Wyo., and in the Black Hills area of South Dakota.

The operation consists of stripping an overburden of from 10 to 30 ft, exposing the 90-ft coal seam, which is strip-mined in conventional manner by means of shovels loading into trucks, discharging into a chunk sizer in a central head house from where the coal is conveyed by rubber belt to the preparation plant. Because of the cleanliness of the coal seam, washing or picking is not required; thus the preparation plant entails normal sizing, dedusting, and oiling. Tonnage from Wyodak mine from 1930 to 1951 inclusive is shown in Table II.

Coal in the Sheridan field is mined both by strip mining and underground mining. The Big Horn Coal Co., mining variably in the Monarch and Carney beds and in what is believed to be the Upper Masters bed, applies strip-mining methods only. A general picture of its operations entails removing overburdens from 10 to 85 ft with large Diesel dragline equipment, having boom lengths up to 130 ft and buckets up to 6 cu yd in size. Some of the overburden requires blasting, but most of it does not and is easily removed. The coal is cut along the high wall with a vertical saw to improve size consist. The coal is blasted and then loaded out with a 4-cu yd power shovel into 15-ton trucks and hauled an average distance of approximately 5 miles to a preparation plant on the main line of the railroad.

The preparation plant consists of a chunk sizer and main screens and rescreens to make standard domestic preparation, as well as industrial and railroad fuel preparation. No picking or washing is required because of the cleanliness of the seam and selective mining. The Carney seam contains a clay parting located approximately in the center of the seam and varying in thickness from a lens to 8 to 10 in.; when this is encountered the coal is taken in two lifts, the top half being removed and the parting cleaned off prior to removing the lower section of the seam.

The Big Horn Coal Co. began operations for the first time in 1943. The Sheridan-Wyoming Coal Co., Inc. came into being in 1920 as the result of a con-

Table II. Wyodak Tonnage, 1930 to 1951

Year	Tonnage	Year	Tonnage
1930	86,611	1941	122,426
1931	92,257	1942	121,435
1932	98,051	1943	119,468
1933	92,136	1944	105,258
1934	113,600	1945	98,355
1935	120,502	1946	174,337
1936	112,782	1947	209,273
1937	112,142	1948	263,266
1938	105,677	1949	314,196
1939	107,923	1950	349,559
1940	118,562	1951	307,074

solidation of six companies operating variously in the Dietz beds and the Monarch and Carney beds. Diminishing market shortly after 1920 forced the closing of several mines, finally confining activities to mining in the Monarch only. At the present time all coal is being produced from one underground mine in the Monarch bed, with a strip operation in the Carney bed as standby for additional tonnage as required. The method of mining entails mining 12 to 16 ft of the Monarch seam on 50-ft centers with room depths to 400 ft. The top coal must be left for roof protection. The top portion of the Monarch bed is interspersed with impurity bands varying from carbonaceous shale to soft clay. The overlying strata is variable sandy shale, shale, and clay beds which are very unstable. The top portion of the Monarch is of inferior quality and as such cannot be marketed. Pillars are recovered on the retreat, and extraction of the mined portion of the bed is approximately 85 pct. The coal is cut with shortwall machines and is drilled with mobile rubber-tired drill equipment. *Airdox* is employed to dislodge the coal, which in turn is loaded out with mobile loading equipment into 10 and 12-ton shuttle cars discharging directly into 3 and 5-ton pit cars, which are hauled to the preparation plant, located on the railroad approximately three-quarters of a mile from the mine portal, by 12 and 15-ton locomotives.

Table III. Analyses of Coal Beds Mined in the Sheridan Field

Bed	Moisture, Pct	Volatile Matter, Pct	Fixed Carbon, Pct	Ash, Pct	Sulphur	BTU
Dietz No. 1	24.7	37.6	33.00	4.7	0.4	8900
Dietz No. 2	22.5	35.3	34.50	6.6	0.9	9040
Dietz No. 3	24.1	31.3	38.5	6.1	0.6	8820
Monarch	22.56	35.49	38.4	3.55	0.52	9502
Carney	26.2	30.2	39.2	4.4		9454
Masters Upper	23.9	34.1	38.2	3.8	0.3	9300

The preparation plant entails main screens, rescreens, chunk sizers, slack sizers, and oil treating plant. Here again, no picking or washing is required because of the cleanness of the coal mined.

Analyses of coal beds mined in the Sheridan field are given in Table III.

The market from the mines in the Sheridan field is common to all producers: domestic consumption, power plants, sugar factories, State and Federal institutions, including Indian agencies, and engine fuel for the Chicago, Burlington & Quincy Railroad.

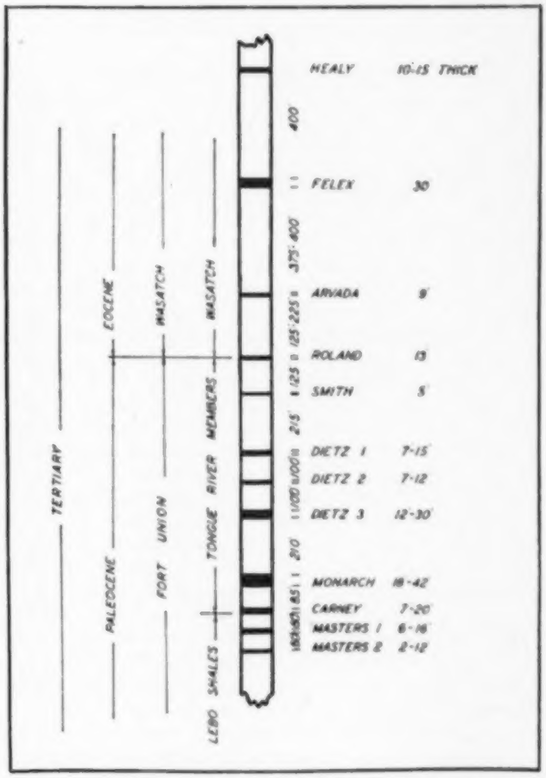

Fig. 3—A stratigraphic chart showing the relation of coal members in the Powder River Basin, Wyoming.

Tonnages from the various mines in Sheridan County from 1930 to 1951, inclusive, are shown in Table IV.

Many inroads have been made into the coal markets by competitive fuels. The development of oil and gas fields in Wyoming and Montana particularly have brought about considerable conversion to oil and gas in industrial and domestic outlets. In addition, the dieselization program of the Burlington

Table IV. Coal Production in Sheridan County, Wyo., 1930 to 1951. From Annual Report of the State Coal-Mine Inspector

Year	Sheridan-Wyoming Coal Co., Inc.	Big Horn Coal Co.	Custer Coal Co. (Armstrong)	Storm King Coal Co. (Black Diamond)	Welch Mine	Star Mine	Total, Sheridan County, Including Wagon Mines
1930	702,226			8,670		8,369	723,338
1931	539,921		3,955	9,250		9,295	565,809
1932	454,083		8,784	11,500		10,695	486,696
1933	412,652		6,716	9,587		11,253	441,405
1934	439,962		2,525	9,711		9,198	465,104
1935	519,157		2,334	8,703		9,253	543,032
1936	642,079		3,510	10,684		7,582	668,514
1937	625,219		1,990	14,423		6,345	651,664
1938	603,599		2,049	14,870		5,721	629,792
1939	557,124		1,723	13,640		7,037	584,183
1940	572,978		1,999	16,512		6,917	606,583
1941	570,025		2,502	15,838		7,175	602,069
1942	754,469		2,308	16,384		8,487	786,251
1943	935,641		2,645	23,514			962,681
1944	1,010,737	107,201		21,906			1,140,658
1945	1,004,540	264,723		20,696			1,290,672
1946	828,268	483,576	1,375	17,074			1,330,877
1947	612,064	551,429	702	16,716			1,181,252
1948	564,551	464,331	2,236	17,280			1,048,713
1949	690,910	425,663	1,920	17,050	12,372		1,147,916
1950	494,622	350,841	4,045	13,674	15,684		878,866
1951	326,826	321,011	2,035	13,219	15,324		680,415

Railroad has reflected a definite reduction in railroad fuel coal consumption.

Big Horn Basin, Northwestern Wyoming

The Big Horn Basin, which includes about 4400 square miles in Big Horn, Park, Hot Springs, and Washakie Counties, is a broad structural basin bounded by the Big Horn Mountains on the east, the Owl Creek Mountains on the south, and the Absaroka Range on the west. The Big Horn Basin is a region of broad dissected plains characterized locally by badland topography. Around the margin of the basin, particularly on the southwest side, the rocks are folded locally into anticlines and synclines. Where coal-bearing rocks are exposed in the anticlines, erosion of the central parts of the structures has resulted in irregular patterns of coal distribution. The coal-bearing rocks in the Big Horn Basin are of Upper Cretaceous age and comprise the Mesaverde, Meeteetse, and Lance formations, and also Fort Union formation of Paleocene age.

The present operations in the Big Horn Basin are in the Gebo field located in Hot Springs County at the southern end of the Big Horn Basin west of the Big Horn River. The coal occurs in the Mesaverde formation of Upper Cretaceous age in a zone between two masses of sandstone. The most important bed is the Gebo, which has a maximum thickness of 11 ft and is more than 5 ft thick along the outcrop. Several other beds, less extensive, are of mineable thickness. The maximum dip is about 25°.

The coal in the Gebo field is of subbituminous B and A rank. An average analysis on the *as-received* basis from the Gebo bed shows:

Moisture, pct	9.9
Volatile matter, pct	36.2
Fixed carbon, pct	39.8
Ash, pct	4.1
Btu	11,760

Mining is generally pursued by either hand loading or shaking conveyors, loading the coal out of rooms which are driven up the dip. The coal is discharged into pit cars on entries driven on the strike. The coal is hauled to partings just off the main slopes, which are generally driven directly on the dip. Rope haulage is used to haul the coal to the tipple. The preparation plants are common main screen affairs, preparing the coal into the simple domestic sizes, such as Lump, Egg, Nut, and Stoker coal. In one instance the coal is prepared at the mine, hauled by truck approximately 5 miles, and loaded into railroad cars. In the other instance, the mine run coal is hauled from the mine to a tipple on the railroad, where it is prepared and discharged directly into the railroad cars.

Lack of market prevents proper exploitation of this field. In 1951 the following companies reported tonnages as follows:

Mine	Tons
Haverlock and MacCullum, Valley Coal Mine	4011.52
Ronceo Coal Co., Ronceo Coal Mine	8765.00
Sheridan-Wyoming Coal Co., Inc. Miller Mine	9510.90
Vlastos Emanuel, Osborne Mine	2179.30
Total	24,466.72

This tonnage indicates a decrease of 12,532.23 tons less than tonnage for 1950.

The market history of the Gebo field is parallel to that of the Powder River Basin, namely, sugar factories, railroad fuel, small power plants, and local domestic outlet.

Mining conditions are generally more difficult in the Big Horn Basin because of folding, faulting, and general inconsistencies of the coal seam. In recent years gas and oil discoveries and subsequent production have cut serious inroads into the coal market from the Big Horn Basin. Of the companies reporting tonnages for 1951, the Ronceo Coal Co. and the Sheridan-Wyoming Coal Company, Inc. were the only rail shippers. In 1952 the Sheridan-Wyoming Coal Co., Inc. sold its interest to the T & T Coal Co., which is now shipping by rail over the facilities formerly owned by the Sheridan-Wyoming Coal Co., Inc. Production tonnages for 1938 to 1951 are given in Table V.

Red Lodge Field, Southwestern Montana

To the north of the Big Horn Basin and in the southwest corner of Montana lies the Red Lodge field, Fig. 4. The first mine in the Red Lodge District was opened previous to 1882, but up to 1889 operations were conducted on a small scale. Operations were increased from 1889 to 1905, in which year nearly 600,000 tons were mined. Tonnage has varied upward and downward considerably from that time to the present. Tonnages for the years 1927 to 1950 are shown in Table VI.

Table V. Production Tonnages, Big Horn Basin, 1938 to 1951

Year	Tonnage	Year	Tonnage
1938	64,206	1945	160,630
1939	65,392	1946	72,480
1940	75,998	1947	69,502
1941	91,909	1948	50,794
1942	137,916	1949	48,430
1943	174,997	1950	24,467
1944	155,387	1951	24,467

Geology: Referring to the lower lefthand corner of Fig. 4, the Red Lodge field is at the foot of the Bear Tooth Mountains in Carbon County, and the coal occurs in the Fort Union formation of Tertiary (Paleocene) age. The Fort Union formation in the Red Lodge field is composed mainly of sandstone and shale and is believed to be about 5000 ft thick. It contains in its upper one-third a coal-bearing zone 825 ft thick between an upper and lower-bearing member. The coal is considered high volatile C bituminous rank because of its resistance to weathering.

Table VI. Production Tonnages, Red Lodge Field, 1927 to 1950

Year	Tonnage	Year	Tonnage
1930	335,081	1940	368,975
1931	261,809	1941	402,324
1932	278,321	1942	622,678
1933	341,388	1943	527,607
1934	273,456	1944	627,617
1935	289,702	1945	555,979
1936	301,932	1946	334,571
1937	361,918	1947	265,693
1938	301,048	1948	235,326
1939	327,996	1949	220,341
		1950	196,626

In the vicinity of Red Lodge eight beds of coal have been worked. They are as follows.

Bed No. 1 contains 7 ft of coal overlain by carbonaceous shale and underlain by 4 to 6 in. of shale above sandstone.

Bed No. 1½, 5 ft of bright coal of many thin partings, has a sandstone roof and shale floor.

Bed No. 2 contains 8 ft of coal in six benches with partings of shale ½ to 1 in. thick. It rests upon shale and is covered by sandstone.

Bed No. 3 contains 10 ft of dirty coal.

Bed No. 4 has 10 ft of good coal occurring in three benches with a parting 1-in. thick 23 in. below the top. This bed is underlain by sandstone and covered by gray shale.

Bed No. 4½ is composed of 3½ ft of coal occuring in several benches and has shale above and below.

Bed No. 5 contains 12 ft 1 in. of coal in four benches, with partings ½ to 2 in. thick, and lies between beds of hard shale.

Bed No. 6 has 4 ft 11 in. of coal in a single bench with sandstone roof and floor.

The coal below Bed No. 6 is placed in one group because the interval between the beds is not sufficient to allow any one coal to be mined without disturbing those above. Most of the coal mined has been obtained from Beds 2, 3, and 4.

The coal beds dip irregularly from the outcrop on the east side of the field to the southwest at the town of Red Lodge. The dip is 18°, decreasing toward the southeast to 9° in the western part of the Bear Creek district and to 3° a short distance farther south. The coal beds are terminated to the west by the Bear Tooth Mountain fault whose eastern side is down-thrown 500 to 600 ft.

A typical analysis, on an *as-received* basis, of coal from Bed No. 4 at Red Lodge shows a heat value of 10,330 Btu., 12.7 pct ash, and 1.3 pct sulphur.

Mining: The two major operators in the Red Lodge field today are the Montana Coal & Iron Co., Foster Mine, and the Brophy mine of the Brophy Coal Co. The Foster mine is situated 1½ miles south of Bear Creek, Carbon County, Mont., and is served by the Montana, Wyoming & Southern Railroad. This mine is opened by three slopes in the No. 3 coal bed, which averages 78 in. in thickness and dips about 5° in a southwesterly direction. This mine employs approximately 85 men with an average daily production of nearly 600 tons of coal, all of which is top cut and sheared at the working faces with a track-mounted Universal mining machine and loaded directly into 5-ton drop bottom cars with track-mounted and crawler-type loading machines. The estimated life of the mine is approximately 50 years at the present annual rate of production. The total production for 1951 was 134,664 tons. The production from Jan. 1 to July 31, 1952, was 62,712 tons.

The mine is developed by room and pillar method but pillars are not recovered. Entries are driven from 12 to 14 ft in width on 50 and 80-ft centers. The immediate roof throughout the mine consists of friable shale, ranging from 6 to 18 in. in thickness, and the main roof consists of hard shale in some areas and a hard firm sandstone in others. Legs and crossbars are generally used to support the roof in the rooms along the haulageways and in the air courses. Where crossbars are not required, props and cap pieces are used. Trolley locomotives are used to transport trips along the main haulageways, including the haulage slope, and cable reel locomotives are used to service the loading machine in each working section. The coal is hauled to a tipple consisting of a crossover dump cascading coal on to shaking and vibrating screens. Crushing equipment, a dry cleaning plant, and wet washing plant are included to permit all marketable sizes of coal to be prepared.

An average analysis of the coal is as follows:

Moisture, pct	11.1
Volatile matter, pct	34.5
Fixed carbon, pct	39.2
Ash, pct	6.2
Btu	11,190
Sulphur, pct	1.4

The Brophy mine is located about 6 miles east of Red Lodge, Carbon County, Mont., and is served by the Montana, Wyoming & Southern Railroad. The mine was opened in 1922 by the Smokeless and Sootless Coal Co. The present operating company acquired the mine in 1940. The mine is opened by two slopes in the No. 2 coal bed, which averages 74 in. in thickness and dips about 3½° in a southerly direction. Approximately 25 men are employed, and the average daily production is approximately 200 tons of coal.

The coal is undercut at the working faces with shortwall mining machines. Coal is broken down with *Cardox* and loaded directly into shuttle cars with a crawler-type loading machine. Total production in 1951 was 15,249 tons.

The mine is developed by room and pillar method; pillars are recovered by open-end methods and by slab cutting the inby ends with a shortwall mining machine.

The immediate roof overlying the coal bed consists of hard dark shale ranging from 4 to 6 ft in thickness, and the main roof is about 60 ft of hard sandstone. The immediate roof is very friable and generally requires legs and crossbars for support along the haulageways in the rooms and the air courses. Where crossbars are not needed, props and cap pieces are used.

A trolley locomotive is used to haul trips from the loading points to a parting at the bottom of the slope from where an electric hoist, located on surface, hauls the coal to the tipple where the coal is dumped through a crossover dump on to the shaker screen. Tipple equipment consists of shaker and vibrating screens, washing plant for Pea coal, and crusher for sizing.

A representative analysis of the field on the *as-received* basis is as follows:

Moisture, pct	9.5
Volatile matter, pct	35.9
Fixed carbon, pct	48.3
Ash, pct	6.3
Btu	10,603

Market outlets from the two foregoing mines are to the Montana, Wyoming & Southern and the Northern Pacific Railroads, State Institutions, small industrial plants, and the general domestic trade in Washington, Idaho, Montana, and North Dakota.

There are several smaller mines, considered as wagon mines, operating in the Bear Creek field and serving some of the local market. These mines are very low in production, and are therefore not mentioned here.

Bull Mountain Field, Central Montana

Geology: Referring to Fig. 4, the Bull Mountain field, located mainly in Musselshell and Yellowstone Counties, is at present the largest commercial producing area in Montana. The coal-bearing rocks in the field are the Tongue River member of the Fort Union formation and to a lesser extent the underlying Lebo shale member of the Tullock formation, see Fig. 5.

The coal is of subbituminous B and subbituminous A rank. Most of the mining is in the Roundup bed, which crops out in the north and northwest part of

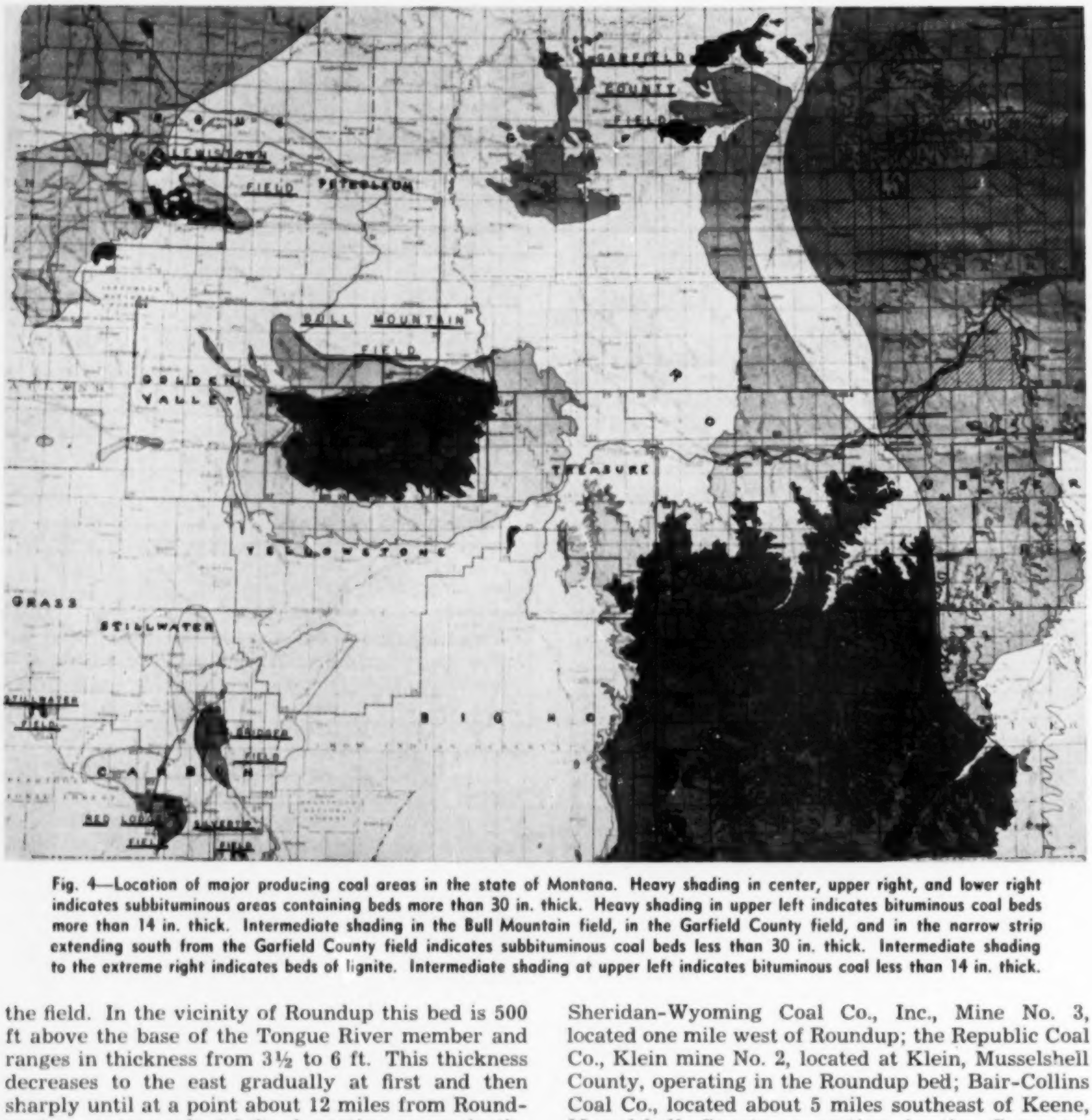

Fig. 4—Location of major producing coal areas in the state of Montana. Heavy shading in center, upper right, and lower right indicates subbituminous areas containing beds more than 30 in. thick. Heavy shading in upper left indicates bituminous coal beds more than 14 in. thick. Intermediate shading in the Bull Mountain field, in the Garfield County field, and in the narrow strip extending south from the Garfield County field indicates subbituminous coal beds less than 30 in. thick. Intermediate shading to the extreme right indicates beds of lignite. Intermediate shading at upper left indicates bituminous coal less than 14 in. thick.

the field. In the vicinity of Roundup this bed is 500 ft above the base of the Tongue River member and ranges in thickness from 3½ to 6 ft. This thickness decreases to the east gradually at first and then sharply until at a point about 12 miles from Roundup it measures only 1.6 ft. A parting occurs in the northwestern part of the field and is variable in thickness from a trace to approximately 24 in. There are from 2 to 3 ft of coal above the parting and approximately 3 ft below the parting.

The Carpenter Creek bed is about 50 ft below the Roundup bed and is commercially important in the northeastern part of the field, where it ranges in thickness from 4 to 8 ft. The Lebo shale member of the Fort Union formation contains, for the most part, only carbonaceous shale in the Bull Mountain field.

The Big Dirty coal bed, which occurs near the middle of the member, ranges in thickness from 22 to 24 ft, but although it is a prominent marker in the field, it contains only 2 in. to 1 ft of clean coal. Economically this bed is unimportant.

The Mammoth and Rehder beds are two coal beds separated by an interval in places so slight that the coal can be mined as a single bed; in other places the interval is as much as 25 ft. The Mammoth outcrops in Township 7 North, Ranges 26, 27, and 28 East, and in Township 6 North, Ranges 26, 27, and 28 East.

Mining: The larger producers in the field are Sheridan-Wyoming Coal Co., Inc., Mine No. 3, located one mile west of Roundup; the Republic Coal Co., Klein mine No. 2, located at Klein, Musselshell County, operating in the Roundup bed; Bair-Collins Coal Co., located about 5 miles southeast of Keene, Musselshell County, operating in the Carpenter Creek bed; and the Jeffries Coal Co., Carlson-Jeffries mine, located 7 miles southeast of Roundup, Musselshell County, operating in the Mammoth bed.

The foregoing mines comprise the rail shippers in the Bull Mountain field. There are numerous small so-called wagon mines operating in the Roundup and Mammoth beds which will not be mentioned here because of their small tonnages.

The No. 3 mine of the Sheridan-Wyoming Coal Co., Inc. is opened by two vertical shafts and four slopes in the Roundup coal bed, which ranges from 46 to 66 in. thickness, and dips about ½° in the present workings in a southeasterly direction. The main haulage slope, which follows the coal from the crop, has a considerable catenary, ranging from 26° at surface to 2½° at the bottom of the slope, which is approximately 3000 ft in length; thence inby to the present workings the grade lessens to ½°.

About 140 men are employed, producing an average of 950 tons per day. The coal is undercut with shortwall mining machines and drilled with hand-held drills. The coal is dislodged with *Airdox*, and

the following combinations of equipment are used to load the coal into pit cars: 1—Crawler type loading machines loading directly into pit cars. 2—Crawler type loading machines discharging into chain conveyors discharging on to rubber belts discharging into pit cars. 3—Crawler type machines discharging to shuttle cars discharging to pit cars.

The 2½-ton pit cars are hauled in 50-car trips by a 36-ton locomotive to the slope bottom parting. An electric hoist, located on surface, hauls the cars up the slope to the tipple in 11-car trips. A rotary dump empties the cars into the tipple from where the coal can be diverted to a chunk sizer, or discharged directly over the main shaker screens where the +2 in. is sized out and passed over picking tables, served by hand pickers, and discharged directly into railroad cars. The −2 in. passes over a secondary rapid shaker screen and is prepared into Nut or Stoker sizes. All sizes can be oil treated.

The total production for 1951 was 149,092 tons; the production from Jan. 1 to Aug. 31, 1952, was 67,336 tons. The estimated life of the mine is approximately 50 years at present rate of production.

The mine is developed by room and pillar method but pillars are not recovered. Main entries are driven three abreast and cross entries in pairs. The main roof consists generally of hard sandstone, but in some parts a hard to friable shale ranging from 2 to 24 in. thickness lies between the main roof and the top coal. A bony streak varying from a trace to 3 in. is generally at the top of the coal, requiring picking the coal in the preparation plant. This mine was opened in 1908 and has operated continually since.

The present market outlet consists chiefly of mill and smelter, State and Federal institutions and plants, and domestic outlet in the states of Washington, Idaho, Montana, North and South Dakota, and western Minnesota.

A representative analysis on an *as-received* basis is as follows:

Moisture, pct	11.0
Volatile matter, pct	24.48
Fixed carbon, pct	54.88
Ash, pct	9.64
Btu	11,126

The Klein No. 2 mine of the Republic Coal Co. is the only other rail shipper mining coal out of the Roundup bed at the present time. This company is owned by the Chicago, Milwaukee, St. Paul & Pacific Railroad and is generally considered a captive operation. It is situated at Klein, Musselshell County, Mont., and is served by the above railroad.

The mine is opened by three vertical shafts and by a 45° slope and it is developed in the Roundup coal bed which ranges from 40 to 64 in. thickness and dips about 1° in a southeasterly direction.

Approximately 110 men are employed at the present time with an average daily production of 1100 tons of coal. The total production for 1951 was 405,144 tons.

The mine is developed by room and pillar method but pillars are not recovered. Main entries and cross entries are driven three abreast about 14 ft wide on 50-ft centers. Rooms are driven about 35 ft in width on 46-ft centers off both sides of the cross-entries and are up to 300 ft long.

The immediate roof consists generally of very soft shale ranging from 22 to 24 in. thickness. In some sections this shale disintegrates rapidly, but in other places it is firm and requires only the regular number of timbers for support. The main roof is generally hard, firm shale, and in some sections massive hard sandstone. The coal is undercut with shortwall mining machines and is drilled with both hand-held and post-mounted drills. Coal is blasted on shift with permissible explosives and loaded out with mobile-type loading equipment. Shaker conveyors had been used in one section of this mine but are not being used at the present time. The coal is loaded directly into 2-ton pit cars and hauled to the shaft bottom by trolley locomotive. An electric hoist on surface provides motive power for hoisting the pit cars to the automatic dump located at the headhouse.

Preparation is achieved in a conventional-type tipple, composed of shaker screen, vibrating screen, crushers, mixing conveyor, and picking table. No effort is made to prepare domestic coal at this mine, practically all of the production being prepared for railroad engine use and industrial use.

A representative analysis on an *as-received* basis is as follows:

Moisture, pct	14.0
Volatile matter, pct	30.8
Fixed carbon, pct	49.5
Ash, pct	5.7
Btu	11,160
Sulphur, pct	0.7

The Carlson-Jeffries mine of the Jeffries Coal Co. is the only other rail shipper in the immediate

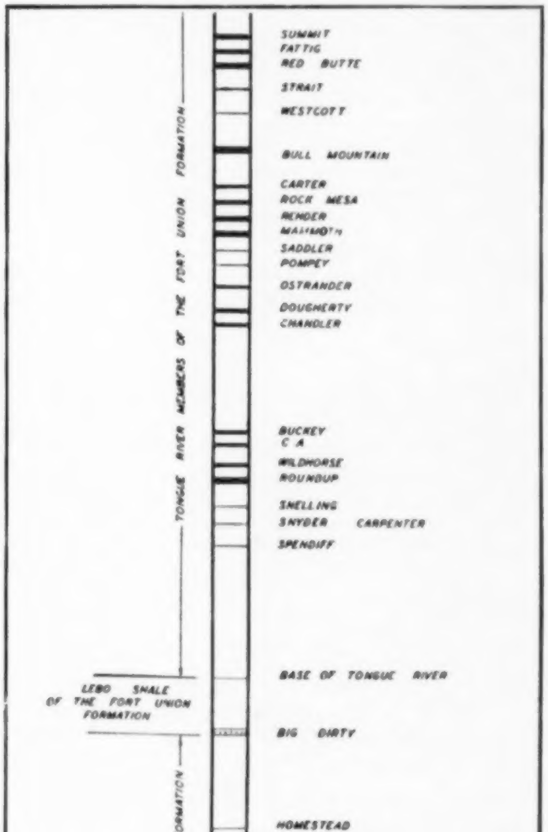

Fig. 5—Coal members in Bull Mountain Field, Montana.

vicinity of Roundup. It is served by the Chicago, Milwaukee, St. Paul & Pacific Railroad.

The mine is opened by three short slopes and two vertical shafts in the Mammoth coal bed, which averages 9 ft in thickness and lies practically level in the area being mined. When this mine was last operated it employed 19 men and produced approximately 150 tons of coal per day, all of which was undercut and sheared with a track-mounted Arc-Wall mining machine and loaded with a crawler-type loading machine. This mine produced in the neighborhood of 20,000 tons per year.

The mine was developed by room-and-pillar method but pillars were not recovered. Entries were driven two abreast about 18 ft in width and 45-ft centers. Rooms were driven about 26 ft in width on 35 to 38-ft centers. The immediate roof consists of unmarketable coal ranging from 3 to 4-ft in thickness. The main roof consists of hard shale about 25 ft in thickness, which is overlain by massive sandstone. The coal was blasted with permissible explosives.

The coal was loaded into pit cars and hauled by a combination storage battery and trolley locomotive from the underground working sections up the slope to the surface to a storage bin. The coal was trucked from the storage bin to the tipple on the railroad, approximately 6 miles distant, where it was prepared into standard domestic sizes for market outlet similar to that described for the Roundup No. 3 mine. At present writing, lack of market has caused this mine to be idle this year.

The Keene No. 2 mine of Bair-Collins Coal Co., located about 5 miles southeast of Keene, Musselshell County, is served by the Chicago, Milwaukee, St. Paul & Pacific Railroad. It is opened by a single entry driven in a southeasterly direction and a vertical shaft 10 ft square and 60 ft deep, and by a single slope driven in a southern direction a distance of 100 ft on the dip of the coal bed, which is the Carpenter Creek coal bed. This bed ranges from 96 to 102 in. thickness; it dips about 3° in a southerly direction.

Forty-five men are employed at the present time, and daily production averages 500 tons of coal. The total production for 1951 was 59,330 tons.

The mine is developed by a room and pillar method but pillars are not recovered. Main and cross entries are driven four abreast and panel entries are driven in pairs 16 ft in width on 65-ft centers. Rooms are driven 26 ft wide on 55-ft centers to a maximum depth of 300 ft. The roof overlying the coal bed consists of hard sandstone about 40-ft thick. Coal is undercut and sheared with a combination top cutting and shearing machine, track-mounted. The coal is dislodged with *Cardox* and is loaded out with a mobile-type loading machine directly into pit cars. Combination trolley and cable reel locomotives are used to serve loading machines at working faces, and a trolley locomotive is used to transport the mine cars along the main and secondary haulage. The coal is discharged at the surface into a bin from where it is hauled in 20-ton trucks to the tipple, 5 miles distant, on the railroad, where it is dumped into a large bin. The coal is conveyed by a 30-in. conveyor belt from the dump to the tipple.

The tipple consists of one triple-deck shaking conveyor, preparing all marketable domestic and industrial sizes.

The market outlet consists of the same types and areas described for No. 3 mine of the Sheridan-Wyoming Coal Co., Inc.

Powder River Basin in Montana, Forsyth Field, Southeastern Montana

Geology: The only other producer in Montana of any consequence at the present time is the Rosebud open pit of Foley Brothers, Inc., located at Colstrip, Rosebud County, Mont. This mine is considered a captive mine in that it supplies coal only for the Northern Pacific Railroad Co. It is an open-pit

Table VII. Coal Production Record for Red Lodge Field and Bull Mountain Field, Montana, 1930 through 1950. Compiled by Montana Coal Operators Association, Billings, Mont.

Company	1930	1931	1932	1933	1934	1935	1936
Bair-Collins Co.	79,852	87,257	113,100	86,277	85,307	128,166	158,273
Montana Coal & Iron Co.	188,370	155,162	175,259	235,397	225,348	227,705	301,932
Roundup Coal Mining Co.	345,816	122,348	131,243	109,964	136,834	171,955	216,421
Now Sheridan-Wyoming Coal Company, Inc.							
Jeffries Coal Co.					56,584	71,135	72,588
Brophy Coal Co.							
Northwestern Improvement Co.	207,896	105,527	53,534				1,225,467
Republic Coal Co.	410,767	414,416	353,264	352,157	340,141	395,551	442,687
Total	1,232,701	884,710	826,400	783,795	844,214	994,512	2,417,368

Company	1937	1938	1939	1940	1941	1942	1943
Bair-Collins Co.	144,723	124,306	116,596	128,569	128,641	170,621	190,986
Montana Coal & Iron Co.	361,918	301,048	327,996	359,141	387,133	595,986	475,925
Roundup Coal Mining Co.	193,891	124,810	136,913	151,734	148,307	201,772	324,881
Now Sheridan-Wyoming Coal Company, Inc.							
Jeffries Coal Co.	61,994	54,111	44,622	28,647	24,298	51,359	63,200
Brophy Coal Co.				9,834	15,191	26,692	51,682
Northwestern Improvement Co.	1,247,337	1,099,106	1,070,734	1,124,932	1,395,943	1,706,749	2,576,627
Republic Coal Co.	364,259	382,234	411,879	440,314	495,917	502,154	516,806
Total	2,374,122	2,085,615	2,108,731	2,243,171	2,595,330	3,255,333	4,200,107

Company	1944	1945	1946	1947	1948	1949	1950
Bair-Collins Co.	150,695	127,712	62,144	79,626	76,838	94,733	75,000
Montana Coal & Iron Co.	576,003	499,810	298,119	241,318	208,557	196,010	182,654
Roundup Coal Mining Co.	384,397	366,219	226,035	213,388	156,341	112,090	123,891
Now Sheridan-Wyoming Coal Company, Inc.							
Jeffries Coal Co.	46,526	42,860	37,890	47,500	36,130	30,380	20,630
Brophy Coal Co.	51,614	56,169	38,452	24,375	26,769	24,331	13,972
Northwestern Improvement Co.	2,513,385	2,555,208	2,452,753	1,962,185	1,893,051	1,819,343	1,708,149
Republic Coal Co.	531,214	529,815	407,812	470,016	432,559	389,844	270,457
Total	4,253,834	4,177,793	3,521,205	3,058,408	2,830,245	2,666,731	2,394,753

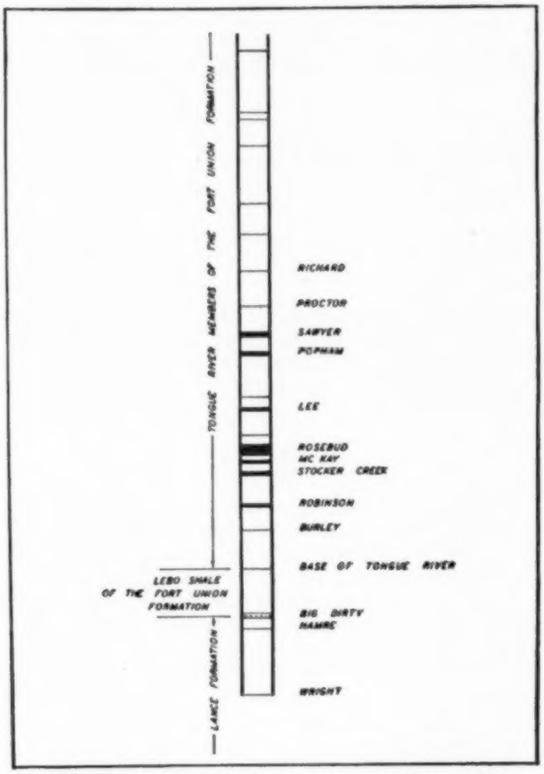

Fig. 6—Chart showing Lance formation and Tongue River members of the Fort Union formation, Forsyth Field, Powder River Basin, Montana.

operation and has been operated since 1924 in the Rosebud coal bed, which averages 26 ft in thickness and dips slightly in an easterly direction.

This bed is 485 ft above the base of the Tongue River member of the Fort Union formation of the Powder River Basin, Fig. 6.

An average of 10,000 tons of coal is produced daily by 88 employees. A total of 1,488,300 tons of coal was produced in 1951, and 746,097 tons were produced during the first seven months of 1952.

Mining: The overburden consists of top shale ranging from 5 to 30 ft in thickness, sand rock from 15 to 30 ft, and shale 30 to 40 ft. The overburden is moved by means of a 13-cu yd and a 20-cu yd electric shovel and relayed with an 8-cu yd dragline. Model D8 bulldozers supplement the stripping shovel operations to remove spillage and other impurities from the top coal bed. The overburden is drilled with churn drills and the vertical holes in the coal are drilled with a jack hammer mounted on a tractor-wagon. All coal is loaded directly into railroad cars by means of a 17-cu yd electric shovel.

Under the present rate of production, this mine is estimated to have a life expectancy of more than 20 years.

Diesel electric locomotives, 600 and 1000 hp respectively, are used to serve the 17-cu yd coal-loading shovels, with trains made up of 12 and 17 railroad cars.

Electric power is received at 69,000 v and transformed to 4100 v for the shovel cables. The shovels are equipped with motor generator sets which convert the 4100 v AC to DC, ranging from 600 to 960 v. All other electrically power-driven equipment is operated at either 220 or 440 v, AC.

An analysis of this coal is as follows:

Moisture, pct	24.4
Volatile matter, pct	28.5
Fixed carbon, pct	39.5
Ash, pct	7.6
Btu	9,080
Sulphur, pct	0.6

In addition to the foregoing described mines, there are approximately 115 small mines scattered througnout the state in the various coal beds and mining tonnages from 10,000 tons annually and less. Tne total production in Montana, all mines reporting, is estimated at 2,410,994 tons for the calendar year 1951.

The production record shown in Table VII[2] indicates tonnages reported on the major mines for the period 1930 through 1950.

Vast reserves of readily mineable coal are located in northern Wyoming and Montana. This area is one of the largest coal-bea.ing areas in the United States. Its potentiality is unlimited. Lack of market outlet is the only reason for the limited exploitation and production of today. The most recent estimate,[3] gives the coal reserves in Montana, short tons, as follows:

Bituminous	2,362,610,000	
Subbituminous	132,151,060,000	
Lignite	87,533,270,000	
Total		222,046,940,000 tons

The coal reserves as estimated in Geological Survey Circular 81, Department of Interior, September 1950,[4] lists the following tonnages in the Powder River Basin and in the Big Horn Basin of Wyoming:

Estimated coal reserves in Montana,		
	Brought forward	222,046,940,000 tons
Bituminous and Subbituminous		
Powder River Basin	94,922,460,000 tons	
Big Horn Basin	581,680,000 tons	
Total		95,504,140,000 tons
Grand total		317,551,080,000 tons

With this grand total of 317,551,080,000 tons in northern Wyoming and Montana, it can readily be seen that this area will prove a valuable asset to the coal industry of America for hundreds of years to come. It is an open invitation to coal-burning industries, steam-generating power plants, chemical plants, and synthetic liquid fuel plants. Impounding of the mountain streams will result in a normal supply of water for vast industries and will aid materially in making use of the great reserve of energy in northern Wyoming and Montana.

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[3] J. X. Combe, D. M. Brown, H. F. Pulver, and D. A. Taylor: *Coal Resources of Montana.* U. S. Geol. Survey *Circ. 53.*

[4] H. L. Berryhill, Jr., D. M. Brown, A. Brown, and D. A. Taylor: *Coal Resources of Wyoming.* U. S. Geol. Survey *Circ. 81.*

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E. L. Christensen, U. S. Bur. Mines, Mine Inspection Department, Billings, Mont.

Localization of Pyrometasomatic Ore Deposits At Johnson Camp, Arizona

by Arthur Baker III

The orebodies are long bedding-plane lenses of chalcopyrite and sphalerite, associated with garnetite masses. Most of the orebodies are within a 50-ft thickness of Cambrian limestone; other Paleozoic limestones and dolomites are locally metamorphosed but only slightly mineralized. Pre-mineral faults are numerous, but shallow folds were the main ore-localizing structures.

JOHNSON camp is in the northwestern part of Cochise County, Ariz., about 50 miles east of Tucson. The nearest major mining districts are Tombstone and Bisbee, respectively 27 and 50 miles to the south, and the Superior-Miami-Globe-Ray porphyry copper group, about 90 miles northwest.

Like many mining camps of the Southwest, Johnson camp is said to have been worked by the Spaniards. The first production on record was in the early 1880's, when an unknown amount of oxidized copper-silver ore in the Peabody mine was mined from replacement orebodies in the Pennsylvanian Naco formation. From 1904 to 1911 outcropping oxidized ores in the Cambrian Abrigo formation were worked, and an estimated 100,000 tons of copper ore were shipped. In 1912 the first large sulphide orebody of the district, the Republic Manto orebody, was discovered, and in the following few years some 250,000 tons of predominantly sulphide ore were shipped. The average grade of this ore was approximately 4.5 pct Cu, 6 pct Zn, 0.8 oz. Ag, and 0.001 oz Au. The Republic, Copper Chief, and Mammoth mines were the principal producers during this period. Mining ceased in the district after 1920, and until 1943 only small-scale leasing operations were carried on.

In 1943 all the mines that had been productive were acquired by the Coronado Copper and Zinc Co., the present operators, and in the 10 years since that time the district production has amounted to approximately 350,000 tons of milling ore averaging 2 pct Cu and 6 pct Zn. Most of this ore was produced from the Republic and Mammoth mines, but since 1950 a large part of the production has been from the new Moore mine.

The total known production from the district, then, is about ¾ million tons of copper and copper-zinc ore of low grade. All of this ore was produced from orebodies associated with garnetite in the middle member of the Cambrian Abrigo formation. In addition to this known production, an unknown tonnage of ore was extracted from the Peabody mine orebodies that lie in the Pennsylvanian Naco formation.

A. BAKER, Member AIME, is Mine Geologist, Johnson Camp Unit, Coronado Copper and Zinc Co., Dragoon, Ariz.

Discussion on this paper, TP 3684I, may be sent (2 copies) to AIME before Feb. 28, 1954. Manuscript, April 30, 1953. Los Angeles Meeting, February 1953.

Published information on the geology of the district is limited. Aside from brief references in various mining journals, only three papers on the district have been published.[1-3] One of these is a U. S. Bureau of Mines report on a diamond drilling program, one is a brief paper on the general geology of the district, and the third is a report on geochemical experiments, with a section on the occurrence of the orebodies. The last two are by John Cooper, of the United States Geological Survey, who has done much detailed work in the area.

Stratigraphy

The rocks of the mineralized area are Paleozoic sediments ranging in age from Cambrian to Pennsylvanian. Several disconformities are present in the stratigraphic column, the most important one being between the Cambrian Abrigo formation and the Devonian Martin formation. There are no angular unconformities. Within the district, the Paleozoic sediments lie in a fairly uniform monocline, striking northwest and dipping 30° to 50° northeast. This local monocline is part of a domal structure centered in the Little Dragoon mountains to the southwest.

The Texas Canyon stock, a quartz monzonite body intruded probably during the Laramide revolution, lies south of the mineralized area (Ref. 2, p. 33). The Paleozoic rocks dip away from the stock, and on the surface are separated from it by at least 1500 ft of Pre-Cambrian rocks. The outcrop pattern of the northeastern edge of the stock suggests that it may dip gently northeastward, passing below the mineralized area at moderate depth. No quartz monzonite has been found in mine workings or diamond drill holes, which reach to depths of 1000 ft. The only igneous rock found in the mineralized area is a lamprophyre dike cutting the Naco limestone in and near workings of the Peabody mine.

With the exception of the lowermost beds—the Bolsa quartzite and the shaly lower member of the Abrigo formation—the Paleozoic sediments are predominantly carbonate rocks, Fig. 1. The middle member of the Abrigo formation, which contains the principal ore-bearing beds, is limestone, with thin shale partings throughout most of its 250-ft thickness. Near the top of this member is a sandy bed some 25 ft thick. The upper member of the Abrigo formation and the lower half of the overlying Devonian Martin formation are dolomitic, with num-

erous quartzite and sandy dolomite beds. The upper half of the Martin formation is principally pure dolomite, while the Mississippian Escabrosa formation and the Pennsylvanian Naco formation are chiefly pure limestone.

Small lenses and stringers of ore minerals occur in all the Paleozoic sediments, and in a few places in the Precambrian rocks. Commercial orebodies, however, are found only in the middle member of the Abrigo formation, with the exception of the Peabody mine orebodies in the Naco formation. The scope of this paper is limited to consideration of the orebodies in the Abrigo formation and their associated metamorphic rocks. The metamorphism associated with the mineralization has affected not only the middle member of the Abrigo formation, but also the impure dolomites of the upper member of the Abrigo formation and the lower half of the Martin formation.

Structure

Faulting: The sedimentary rocks are broken and displaced by three groups of fractures: the Northeaster faults, the Easter faults, and the Northwester faults. Included in each of these three groups are not only faults with appreciable displacement, but also numerous non-displacing fractures that have the same characteristics as the faults but not the displacement. Included in the Northeaster fault group, for instance, are about 30 known faults with displacement, and some 200 identical fractures without displacement.

The Northeaster faults are normal faults striking N 15° to 20° E and dipping 65° to 75° E. On the 30 faults of the group that have appreciable displacement, the movement has been directly down the dip of the fault surface. Two faults of the group displace the beds by as much as 200 ft, but for the others the maximum displacement is 40 ft, the great majority having no displacement at all.

Vuggy, symmetrically banded quartz-orthoclase veins up to 1 ft wide are common in Northeaster fractures where the walls are either ore or metamorphic rocks, but in unmetamorphosed sediments there is usually only a slightly silicified zone a few inches wide. Chalcopyrite, pyrite, bornite, scheelite, argentiferous tetrahedrite, fluorite, wolframite, and galena have been found in the veins. The last four of these are found only in the Northeaster veins; they do not occur in the bedded orebodies. No zinc minerals are found in the veins. The veins are nowhere wide enough to constitute orebodies in themselves, and the sulphides are abundant in them only where the walls of the veins are ore of the bedded orebodies. The sulphides are later than the vein silicates, since they mold around silicate crystal faces and replace silicates along fractures. The walls of most Northeaster fractures are chloritized to a depth of about an inch, regardless of whether the fractures carry sulphides or other vein matter. On all the displacing faults, and on many of the non-displacing ones, this chlorite is strongly sheared.

The faults of the Easter group strike N 70° E to S 70° E, and dip either about 45° S or 80° S. Most Easters are normal faults, offsetting the beds by as much as 250 ft, but one major Easter is a reverse fault with offset ranging from 50 to 150 ft. At most places Easter faults consist of a zone of sheared chlorite that is 3 in. to 3 ft thick, with occasional fragments of partially chloritized wall-rock embedded in the chlorite. Where the faults pass through orebodies, this main zone is in places bordered by a zone in which the ore wall rock has been shattered and then partially replaced by chlorite along the fractures. The chlorite in these zones is sheared like that of the zones of major movement, but the wall-rock fragments have been neither rotated nor moved any appreciable distance. In rare instances, at or near the intersections of the Easter faults with orebodies, chalcopyrite occurs in the fault zones, intergrown with unsheared chlorite. In one small area of an Easter fault zone, molybdenite is found as a replacement of chlorite along the shear surfaces.

Faults of both the Northeaster and the Easter groups are distributed uniformly throughout the district. Northwester faults, however, are common only in the western end of the district and are almost entirely absent toward the eastern end. The Northwester faults strike about N 10° W and dip steeply either east or west. The maximum known displacement is 150 ft. The Northwester fault zones locally contain quartz veins similar to those of the Northeaster faults, but more commonly they are simply sheared zones a few inches to a few feet in width.

Movement on all three groups of faults was essentially contemporaneous, as is shown by the fact that faults of each group are cut and offset by faults of the other two groups at one place or another in the district. The initial development of the faults began before the metamorphism and mineralization, since faults of both the Northeaster and Easter groups locally influenced the distribution of the metamorphic rocks and ore. Ore fragments found in the shear zones of faults of all three groups demonstrate that some of the movement was later than the mineralization. The final fault activity in the district was the movement that produced the 100-ft and greater displacements on the major Easter faults, since these Easters offset all the faults of the other two groups they intersect.

Folding: Superimposed on the regional monocline of the Paleozoic sediments are two sets of shallow

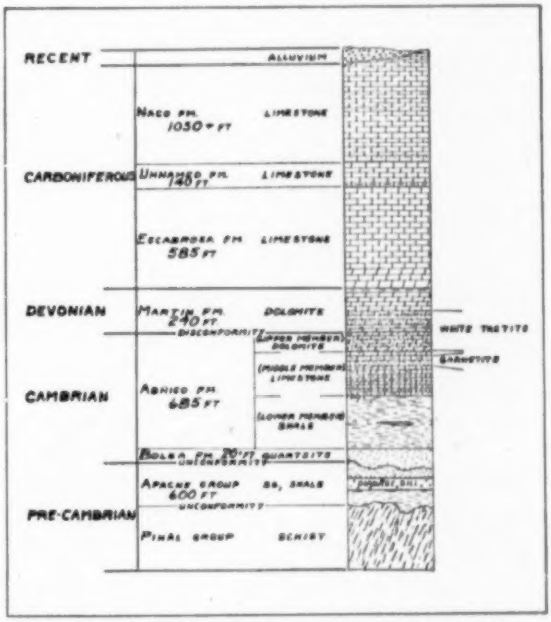

Fig. 1—Diagrammatic section of rocks at Johnson Camp. (After Cooper, Arizona Bur. Mines Bull. No. 156.)

warps, the Manto folds and the Winze folds. The axes of the two sets of folds are at right angles to each other: the Manto folds trend between due East and S 70° E and plunge 15° E, while the Winze folds trend about N 10° W and plunge 30° N. Folds in both groups are best developed in the ore-bearing beds, decreasing in intensity above and below these beds. Although all the folds are very shallow, some of them are at least 700 ft long.

The most completely developed fold in the district is the Republic Manto fold, which along part of its length is an anticline some 150 ft broad with about 20 ft of closure. The four other known Manto folds are simply structural terraces not more than 60 ft wide, Fig. 2. The axial plane of the Republic Manto fold dips steeply south, but the axial plane attitudes of the other Manto folds are not known. All the known Manto folds lie approximately parallel to the intersections of major Easter faults with the beds, but from 50 to 150 ft away from these intersections. The parallelism suggests that the two kinds of structures are genetically related. The Manto folds are somewhat earlier than the Easter faults, however, since in one case a Manto fold is cut off by a warped portion of an Easter fault.

The Winze folds are much less clearly defined than the Manto folds, and in some cases the presence of a fold is inferred from very limited evidence. The difficulty in outlining Winze folds stems principally from their extreme shallowness; the presence of numerous small faults further complicates the matter. The most well-exposed of the Winze folds is the Northeast Winze fold, an anticline some 300 ft broad with 15 ft of closure, Fig. 3. Of the two other known Winze folds, one is a shallow syncline 150 ft broad and the other an anticline 75 to 150 ft broad with scarcely discernible closure. Where the folds cannot be directly mapped, their presence is inferred from changes of a few degrees in strike and dip of the bedding.

The axial plane attitudes of the Winze folds are unknown. The folds trend approximately parallel to the strike of the Northwester faults, but two of the Winze folds are 500 ft from the nearest Northwester fault, so a genetic relationship is doubtful.

Both the Manto folds and the Winze folds are offset by faults of the Northeaster and Easter groups and are therefore older than those faults. There is no direct evidence as to the ages of the folds relative to the Northwester faults, but probably the folds are older than those faults also. Since the faults are older than the metamorphism and mineralization, the folds must also be older, a conclusion that is borne out by the fact that nearly all of the ore and some of the metamorphic rocks of the district are localized in shoots lying along the axes of folds of both groups.

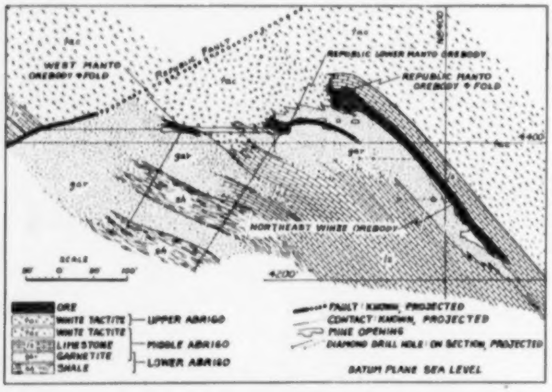

Fig. 2—Cross-section A-A' through Republic mine, showing relationship of metamorphic rocks and ore to structure and stratigraphy.

Metamorphism and Mineralization

Description of the Rocks: Two kinds of rocks resulted from the metamorphism at Johnson Camp; they are known locally as white tactite and garnetite. A third type of rock, formed during the mineralization phase rather than in the metamorphic phase, is the ore itself.

The white tactite is a very fine-grained greenish-gray to white rock, composed of diopside, quartz, and orthoclase. Diopside is the predominant mineral, making up from 40 to 80 pct of the rock, either quartz or orthoclase or both making up the remainder. Diopside grains are subhedral to euhedral, and always less than 0.5 mm in diam, while quartz and orthoclase form ragged intergrown masses with a maximum dimension of about 5 mm. In a few thin sections, beds of fragmental orthoclase are found.

The garnetite is a coarser-grained reddish rock made up of roughly 50 pct grossularite, 30 pct diopside, and 20 pct quartz and/or calcite. As in the tacite, the diopside is in very small subhedral to euhedral grains, while the quartz and calcite form irregular masses. Much of the grossularite occurs in bands composed of nearly pure grossularite, and in these bands it forms anhedral grains up to 5 mm in diam. Outside these bands, where crystals did not interfere with each others' growth, the grossularite is euhedral. Two types of grossularite, both of them anisotropic, are always present. The older type, which forms the cores of isolated crystals and makes up the bulk of the purer grossularite bands, is dodecahedrally twinned. The younger type, which forms euhedral rims around cores of the older type, is twinned in concentric bands parallel to the rims. This younger grossularite contains a relatively high proportion of manganese.

The ore of the district is markedly banded parallel to the bedding, the sulphides and associated minerals being concentrated in bands from 2 to 14 in. thick, separated by bands of garnetite waste of similar thickness. Aside from scattered spots of sulphides, the garnetite bands are barren. The grade of the sulphide bands is approximately constant, so that the grade of ore broken depends largely on the relative thickness and number of sulphide bands and garnetite bands.

The minerals of the sulphide bands are sphalerite, chalcopyrite, tremolite, chlorite, calcite, pyrite, bornite, molybdenite, scheelite, magnetite, and hematite. These minerals everywhere occur together, and in thin section they are seen to be invariably younger than the minerals of the metamorphic rocks. They form a genetic group distinct from the metamorphic minerals. Sphalerite and chalcoyprite are the most abundant minerals of the group, making up the bulk of the volume of the sulphide bands. Tremolite, chlorite, and calcite are the most consistently abundant of the gangue minerals; only scattered crystals of the others occur in most of the ore.

Within the sulphide bands, which are more or less continuous over the entire length and breadth of a single orebody, sulphides often form nearly solid masses, with only scattered grains of gangue minerals. The only garnetite minerals present are cor-

roded crystals of grossularite and occasional remnants of diopside grains. Since the intervening garnetized beds were so unfavorable for sulphide deposition, it is probable that the beds that now contain the sulphides were at no time very throughly garnetized. This conclusion is supported by the fact that at the edges of orebodies sulphide bands often grade out into ungarnetized limestone, while the intervening garnetite bands continue several feet or yards beyond the ends of the sulphide bands.

Outside the orebodies, sulphides occur in scattered small spots in both garnetite and white tactite. For the most part these spots are concentrated in particular beds of the metamorphic rocks, and the bulk of the rocks are barren. In these disseminations, as in the orebodies, the sulphides and their associated minerals are everywhere younger than the metamorphic minerals.

Localization of Ore and Metamorphic Rocks: Stratigraphy was a highly important factor in localizing both the white tactite and the garnetite. Garnetite was formed only in the limestones of the Middle Abrigo and in limy lenses of the Lower Abrigo, while with rare exceptions, white tactite was formed only in the impure dolomites of the Upper Abrigo member and the lower half of the Martin formation. The known exceptions to this latter rule are two areas in which Middle Abrigo limestones, which would normally be garnetized, are tactitized in the footwall of major Easter faults. The most notable such area is in the Republic mine, where a pipe of white tactite 150 ft thick (stratigraphically), 200 ft wide (down the bedding dip), and 1500 ft long lies under the Republic fault, an Easter fault, see Fig. 2.

Within the beds favorable for its formation, the white tactite is much more widely distributed than are the garnetite or the ore in their favorable beds. Throughout the explored part of the district—about 10,000 ft along the strike and 2000 ft along the dip of the beds—most of the beds of the impure dolomites have been altered to very uniform white tactite, regardless of variations in proportions of silica and dolomite from bed to bed in the original sediments. The beds most resistant to the tactitization were the purer quartzites and dolomites. In some areas, particularly above orebodies, even these resistant beds are thoroughly tactitized.

The limestones were much less uniformly metamorphosed. Although the entire thickness of the Middle Abrigo and part of the Lower Abrigo were garnetized around the area of abnormal tactitization below the Republic fault, only the uppermost 75 ft of the Middle Abrigo were consistently favorable for garnetization, Fig. 2. These beds, from the bottom up, are 30 ft of limy sandstone; 20 ft of coarse-grained limestone; and 25 ft of similar limestone with numerous shale beds up to 3 in. thick. The top of the uppermost bed is the contact with the tactitized Upper Abrigo. Usually only the sandstone and the non-shaly limestone are garnetized, but in some disturbed areas the shaly limestone also is garnetized. The beds below the sandstone are rarely altered. Even within these beds most susceptible to garnetization, large areas are essentially unaltered: outside the abnormally metamorphosed areas, nearly all of the garnetite is confined to distinct shoots.

Four garnetite shoots are known in the district: the Northeast winze and 760 garnetite shoots in the Republic mine, Fig. 4, and two others in and near the Moore mine, at the western end of the district.

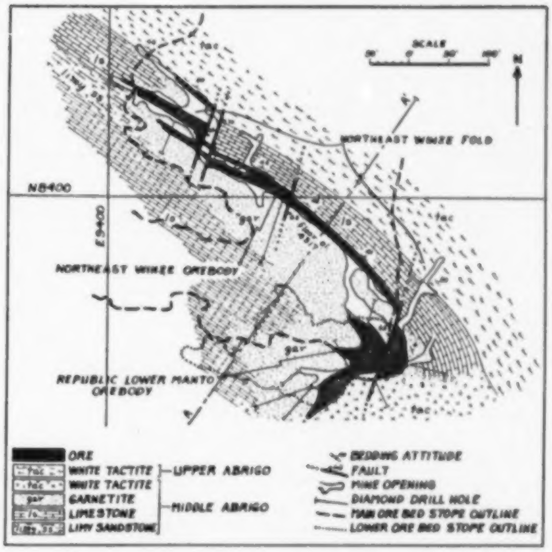

Fig. 3—Geologic map of Republic mine 1100 level, showing ore localized in shallow Winze fold.

Three of these shoots contain ore as well as garnetite. The shoots are at least 500 ft long and from 100 to 300 ft wide. The thickness ranges from 50 ft in places where only the most susceptible beds are garnetized to 75 ft where the overlying limestone as well is garnetized. Within the shoots, most of the rocks are thoroughly garnetized, except some of the purer bands of the sandstone bed and the ore-bearing portions of the shoots, where as much as 50 pct of the rock may be ore. The hanging walls and footwalls of the shoots are bedding planes, and therefore quite regular, but the lateral edges are very irregular in cross-section, since the extent of garnetization along individual thin beds is variable.

The long axes of three of the garnetite shoots trend N 10° W, and in each of these shoots the outline of Winze folds can be discerned locally, but the folds are too shallow to be traced continuously along the entire length of the shoots. The fourth garnetite shoot is known only from diamond drill hole exposures, so no fold can be distinguished. The shoot trends easterly, however, so it is inferred to lie along the axis of a Manto fold.

Besides these four garnetite shoots and the mass of garnetite below the Republic fault, two other masses of garnetite are known in the district, and the presence of several others is indicated. Exposures of these masses are too limited, however, to determine whether they are distinct shoots like those described above or irregular bodies.

The mineralogical composition of the metamorphic rocks, as well as their distribution, demonstrates the importance of stratigraphy in their localization. The white tactite, which is composed largely of diopside, with two exceptions was formed only from dolomitic sediments. The garnetite, composed largely of grossularite with minor amounts of diopside, was formed only from limy sediments. The distribution of the metamorphic rocks within their chemically favorable beds is also in part a reflection of their stratigraphic characteristics as to permeability and competence. The dolomites were evidently highly permeable at the beginning of metamorphism, since they were widely tactitized.

Whether this permeability was due to porosity or to shattering is not known. The limestones, on the other hand, were not generally permeable, but because of their competency they were shattered along zones of structural deformation. The garnetization, therefore, was limited to deformed zones where the metamorphosing solutions could penetrate the rocks.

Structures were evidently of minor importance in localizing the white tactite, except in the cases of the anomalously tactitized areas of the Middle Abrigo. Here faults seem to have acted as barriers, but their exact mechanism and the chemical processes that took place are not known. In the dolomites, where white tactite was the normal result of metamorphism, the only indication of structural control is the presence of areas more intensively tactitized than usual above ore and garnetite shoots.

Both faults and folds localized garnetite masses, and the total volume of garnetite localized by each kind of structure is about the same. However, the garnetite localized by a fault is all in one large mass, beneath the Republic Easter fault, while there are four separate shoots of garnetite localized by folds. In general, therefore, it may be said that folds are more common than faults as localizing structures for garnetite.

For practical purposes the ore, like the metamorphic rocks, can be considered partially localized by stratigraphy: with three small exceptions all the orebodies lie in the uppermost 50 ft of the Middle Abrigo member. The most persistently ore-bearing bed is the non-shaly limestone that is also commonly garnetized, but locally ore extends into the beds above and below.

All the orebodies lie within garnetite masses, the sulphides being interlayered with the uppermost beds of garnetite. The orebodies associated with distinct garnetite shoots such as the Northeast Winze and 760 Winze orebodies of the Republic mine have the same general size and outline in horizontal projection as do their containing garnetite shoots, Fig. 4. The orebodies in the anomalously metamorphosed area of the Republic mine are much smaller than the garnetite mass, but their axes are parallel to the long axis of the area. The three orebodies occurring outside the main ore-bearing beds are in this area. They lie in two lower beds of the Middle Abrigo, but

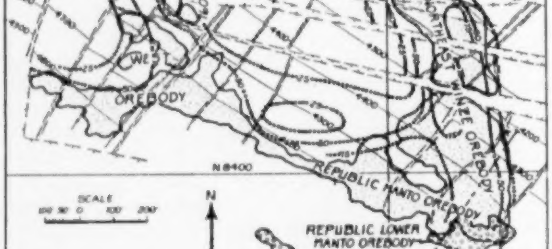

Fig. 4—Republic mine area, structure contour and garnetite isopach map. Outlines of orebodies projected to horizontal plane.

because the Middle Abrigo is here anomalously tactitized, they are nonetheless in the uppermost part of the garnetite, Fig. 2.

This confinement of ore to the topmost garnetized beds, whatever their stratigraphic position may be, suggests that the top of the garnetite, rather than any particular bed, forms the favorable ore zone. Evidently the mineralizing solutions were active only in the uppermost beds that had been previously garnetized. Throughout most of the district, however, only beds near the top of the Middle Abrigo were garnetized, so that in most instances the ore is somewhat distantly localized by stratigraphy.

Most of the orebodies of the Middle Abrigo are elongate lenses from 12 to 40 ft thick and 35 to 300 ft wide. The length ranges from 150 to 800 ft. The orebodies lie along the axes of either Manto or Winze folds, and their dimensions are largely reflections of the character of the folds containing them. Orebodies lying in the broad shallow Winze folds are wide and thin, while those lying in the narrower, tighter Manto folds are narrow and relatively thick. An exception to this general rule is the West orebody of the Republic mine, which is a broad irregular lens with variable thickness, Fig. 4. Its irregularity probably results from the fact that it lies at the junction of the Republic Manto orebody and the 760 Winze orebody and therefore has some of the characteristics of both, as well as features not found in either.

Courses and Timing of the Mineralizing Solutions: The close spatial relationship between the garnetite bodies and the orebodies demonstrates that the two are closely related genetically, even though the microscopic evidence shows the sulphides to be invariably later than the metamorphic minerals. In all probability, the metamorphic rocks were formed by early solutions, and the orebodies were formed by later solutions from the same source. There was probably no hiatus between the kinds of solutions, but rather a partial overlap. The white tactite was formed during the early stages of solution flow, the metamorphism sealing off the rocks, so that the later mineralizing solutions were unable to penetrate them in any appreciable amount.

The long narrow shape of the garnetite and orebodies, as well as their continuity, suggests that these bodies mark the principal channels in which the solutions flowed. In other words, the ore solutions flowed along the present length of the orebodies and parallel or nearly parallel to the bedding, rather than flowing across the beds and the present orebodies and replacing the favorable beds while leaving the surrounding areas unmineralized. Further evidence for this conclusion is found in variations of the textures of the ores from different parts of the district as described below.

In all the ore, the sphalerite contains numerous blebs of chalcopyrite ranging in size from 0.003 mm to 0.1 mm in diam. The pattern formed by these blebs within individual sphalerite crystals is roughly the same throughout the district: around the edge of each crystal is a narrow zone, some 0.2 mm wide, in which there are no blebs, and within this is a zone about 0.7 mm wide in which blebs are abundant, Fig. 5. In this latter zone, blebs increase in size from the outer edge inward. Variations in the pattern of the blebs appear in the centers of the grains. In the deeper portions of orebodies, the grain centers are nearly filled with large blebs, but in shallower ore the blebs are smaller and less numerous. In some of

Fig. 5—Relations between sphalerite and chalcopyrite in ore typical of the deeper levels of the Republic mine. X50.

the very near-surface ore, the centers of the sphalerite grains contain no chalcopyrite at all. This change in the pattern of the chalcopyrite blebs is recognizable not only from orebody to orebody, but also along the length of individual orebodies. Thus in the Republic mine, the centers of sphalerite grains from the deepest workings on the Northeast Winze orebody contain numerous large blebs; higher in the same shoot the blebs are smaller. This progressive change does not stop at the top of the Northeast Winze orebody, where the ore takes a sharp change in direction and acquires a new name, the Republic Manto orebody, Fig. 4. Along the length of this orebody the diminution in bleb size continues, showing that the Northeast Winze and Republic Manto orebodies are genetically a single orebody, in spite of the marked change in their shape and direction.

The reason for this change in the character of the chalcopyrite blebs in the sphalerite is unknown. For the present purpose, the important point is that the change is progressive along the length of the orebodies, indicating that the solutions that deposited the sulphides flowed along the present long axes of the orebodies. It is difficult to conceive of any other possible course the solutions might have taken and yet formed the orebodies and caused this progressive change in texture.

On the basis of this evidence, then, the course of the mineralizing solutions must have been approximately as follows. The earliest, metamorphosing solutions reached the exposed area at the bottoms of the Northeast and 760 Winze orebodies and flowed upward from there. Most of the solutions stayed in well-defined channels near the top of the Middle Abrigo member and formed garnetite bodies, but some leaked into the overlying dolomites and altered them to white tactite. The solutions in the principal channels were partially dammed by the Republic fault and formed below it a large mass of metamorphic rock. It is possible that solutions from another channel, following the Republic fault, were introduced in this area. The later mineralizing solutions followed the same principal channels in their lower parts, forming the Northeast and 760 Winze orebodies by replacing the purer limestone bands that had resisted garnetization. The solutions coming up the Northeast Winze channel were diverted by the mass of metamorphic rock under the Republic fault and flowed westward along the edge of this mass, forming the Republic Manto orebody. Eventually these solutions joined those coming up the 760 Winze channel to form the West orebody. The mixed solutions from the two channels then continued westward, still along the edge of the mass of metamorphic rocks, above the present erosion surface. Probably the three small orebodies within the mass of metamorphic rocks under the Republic fault were formed by solutions that reached the area by some channel not yet located; the sulphide textures of these orebodies indicate that they are not offshoots from the other orebodies.

Conclusions

Stratigraphy was the agent of primary importance in localizing the metamorphic rocks and the ore in the Johnson Camp district: white tactite was formed for the most part only in the impure dolomites, while garnetite and ore were formed only in the limestones. Chemical differences between the dolomites and the limestones were largely responsible for the mineralogical differences between white tactite and garnetite.

Structure was of little importance in the localization of the white tactite; this rock was formed in the favorable beds all through the district, probably because they were quite uniformly, though not highly, permeable. Structures were very important, however, in further localizing the garnetite and ore in certain parts of the limestones. Throughout much of the district, shallow folds shattered beds in the upper part of the Middle Abrigo member enough to make them highly permeable. The metamorphosing and mineralizing solutions used these shattered zones as channelways and formed garnetite and orebodies along them. In rare instances, major faults dammed and diverted the solutions from these fold-axis channels, causing the formation of large masses of metamorphic rocks, but in general faults were of minor importance in localizing both the metamorphic rocks and the ore.

The structural localization of garnetite and ore is to some extent related to stratigraphy as well, in that only certain beds were of the proper competency to be shattered by the folding.

Acknowledgment

The writer is indebted to the Coronado Copper and Zinc Co. for permission to present this paper.

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Mineralization and Hydrothermal Alteration In the Hercules Mine, Burke, Idaho

by Bronson Stringham, F. McIntosh Galbraith, and Garth M. Crosby

THE Hercules mine is located in the northeastern section of the Coeur d'Alene district, approximately 1½ miles north of the town of Burke, Idaho. Surface indications of the ore deposit were first discovered in 1886, but regular mine production was not started until 1902 and was continuous until April 1925, when the known ore had been extracted. Incomplete records show that from 1912 until operations were suspended the mine produced 2½ million tons of ore containing 9.4 pct lead and 7.7 oz of silver per ton, together with an estimated 2 pct zinc, 0.3 pct copper, and 20 pct iron. This operation was the first in a series of mining enterprises culminating in October 1947 with the consolidation of Day Mines, Inc. In the same year it was decided to unwater the levels below the collar of the Hercules shaft in the hope of finding some indication of a recurrence of ore. The unwatering operation has been described in a previous paper.[1] The initial exploration, following recapture of the workings, showed sufficient promise to warrant a detailed study of the mineralogy with modern techniques.

The general geology of the Coeur d'Alene district, including a detailed description of the rock types encountered, has been comprehensively treated by Ransome and Calkins[2] in their classic paper, and only local background description, therefore, is felt to be appropriate here.

The Hercules deposit transects a portion of the trough of a broad south-trending synclinorium which has been greatly complicated by faulting. More locally, it lies within a block of ground bounded on the east by the O'Neil Gulch fault, a steep north-south overthrust of considerable magnitude, and on the west by a monzonite stock, the outcrop of which is ½ mile or more wide and 5 miles long. The country rock is composed of thin to medium-bedded argillites and argillaceous quartzites of the Prichard and Burke formations, the oldest members of the Pre-cambrian Belt Series of sediments in the area, believed to be of Algonkian age. The contact between them is a conformable gradation. The argillite is colored gray to tannish-gray and is fine-grained, compact, and generally massive in structure. Under the microscope the unaltered argillite is seen to be composed principally of anhedral quartz and a few feldspar grains which were at one time presumably partly rounded sand grains, but as a result of recrystallization and cementation by silica, the interstices are now almost obliterated and quartz grains show crenulate boundaries. The sizes of these crystals vary from 0.5 mm down to 0.1 mm in greatest dimension. In all specimens sericite comprises 10 to 20 pct of the rock and is present abundantly between most of the grains as flakes or shreds which vary considerably in size. Sometimes they form a fine felt-like mat or aggregate, and sometimes flakes are seen which appear to be good muscovite. In some specimens, separated rhombic-shaped carbonate grains are abundant, and in some instances these have been changed to sericite.

B. STRINGHAM is Chairman, Department of Mineralogy, University of Utah, Salt Lake City. F. M. GALBRAITH and G. M. CROSBY, Members AIME, are, respectively, Chief Geologist and Senior Geologist, Day Mines, Inc., Wallace, Idaho.

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Mining operations to date have explored the Hercules vein to a maximum vertical depth of 3600 ft below its outcrop, and along a maximum strike-length of 3600 ft on certain of the lower mine levels. The main orebody is irregular in outline, extending over a variable strike-length of 400 to 1500 ft; and it is intersected by a strong transverse fault that has been traced from the surface to the bottom level. This has been named the Hercules fault, and apart from the vein itself, it is the most prominent structural feature in the mine. There is good evidence that it existed prior to the introduction of ore solutions and may have influenced ore deposition, but it was also the locus of important post-ore displacement and shows a progressive right-handed horizontal component reaching 200 ft on the deeper levels. Its vertical component is not definitely known but may be considerably greater. The fault strikes 20° N to 50° E and dips westerly at angles of 70° to 45°, flattening in dip where it crosses the original orebody from east to west between 1000 and 1600 ft below the surface. At about 3000 ft in depth the Hercules fault is joined by a vertical fault of similar strike, and the major post-ore displacement below their junction is taken up along this vertical branch of the structure, now called the Mercury fault. Recent work has been concentrated in this vicinity. Another structural feature of special geologic interest, though of little economic importance, is the occurrence of a porphyritic dike in this area. This lies a short distance above the Hercules fault, essentially parallel to it, and is 5 to 15 ft in thickness. It appears at first glance to cut the mineralization, suggesting *push-apart* relationship, but small stringers of the vein minerals have been observed to penetrate the dike for a matter of inches at several points. The dike is thought to be related to the monzonite intrusion.

A vertical longitudinal projection of the mine is shown in Fig. 1, which illustrates most of the features discussed above.

The Hercules vein was deposited along the course of a strong, persistent shear zone that now appears as a braided network of gouge seams running through more or less crushed and shattered country rock. It strikes 70° N to 80° W and dips southerly at an average of 75°. Barren parts of the structure vary in width from less than 1 ft to more than 15 ft. The width of mineralized segments may be double that. Although the evidence is not conclusive, premineral, normal movement along the zone may be 1000 or 1500 ft. The horizontal component is unknown. Post-ore movement appears to have been

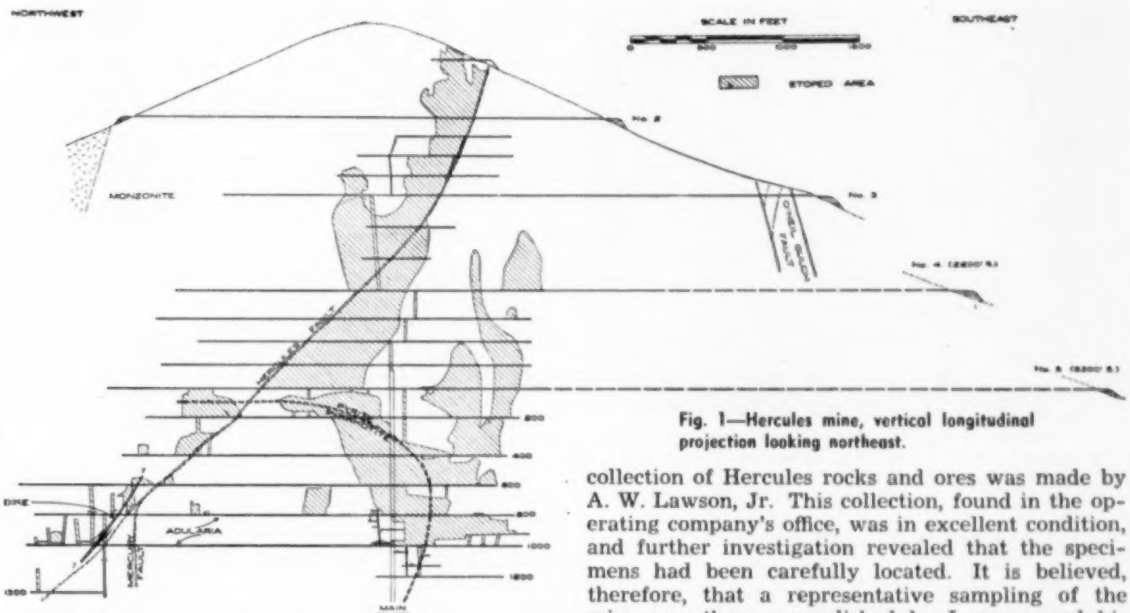

Fig. 1—Hercules mine, vertical longitudinal projection looking northeast.

insignificant, although moderate shearing can frequently be observed on the walls of the vein, more commonly on the footwall, resulting in a well defined *slip*. The common vein pattern shows a principal strand of massive mineralization accompanied by a variable width of parallel or branching stringers in either or both walls, so that the total width of mineralization is not uncommonly twice that of the main vein.

The mineral assemblage is particularly interesting and includes silicates, carbonates, oxides, and sulphides. The principal gangue minerals are pyrrhotite, magnetite, siderite, grunerite, and quartz with subordinate amounts of pyrite, calcite, biotite, garnet, and chlorite. The ore minerals are galena and sphalerite, with sporadic minor occurrences of chalcopyrite. Although the high-grade ore appears most commonly as irregular masses within the vein, a poorly developed banding of minerals can usually be seen, parallel or at low angles to the vein walls. The mineral textures vary from dense to coarsely crystalline with little apparent relation to vein widths, and one rather suggestive texture is a peculiar alignment of crystals simulating gneissic structure that is occasionally noted in the coarse galena. The vein mineralization as a whole is believed to have been deposited predominantly by filling, replacement playing a subordinate role.

Development of Hydrothermal Minerals in or Near the Hercules Fissure

Studies of the hydrothermal history of the minerals in or near the Hercules fissure began in the summer of 1950 when nearly 100 specimens were collected from the mine for detailed observation. Thin sections and polished sections were prepared of most of the specimens, and during the late summer and fall of the same year the mine was revisited and laboratory investigations were completed. The open lower levels of the mine were examined in considerable detail. Some of the older upper levels were also inspected, but because of their inaccessibility, detailed observations on these levels were not possible. During the 1920's, when the mine was in full operation and most of the levels were open, a collection of Hercules rocks and ores was made by A. W. Lawson, Jr. This collection, found in the operating company's office, was in excellent condition, and further investigation revealed that the specimens had been carefully located. It is believed, therefore, that a representative sampling of the mine was thus accomplished by Lawson, and his samples were freely examined.

Openings in the mine are largely confined to the fissure proper, and the scarcity of crosscuts available for collection made the study of the rocks transverse to the fissure somewhat limited.

Biotite: A very fine-grained, massive-appearing, black to dark green biotite is the most important and widespread of the minerals formed by hydrothermal alteration and is present throughout the entire mine in or near the main Hercules fissure zone. In a broad general way it is more intensely developed near ore shoots but small amounts are observed in wall rock, at least as much as 15 to 25 ft from the main vein on the lower western levels.

X-rays, differential thermal analyses, and optical properties prove distinctly that this mineral is true biotite. Where it makes up practically 100 pct of the rock, it is very massive in appearance and is colored black to greenish black. It is also very soft, and where tectonic movement has occurred this mineral usually has taken up the slippage and often shows prominent shiny slickensided surfaces. Near the Hercules vein the mineral may appear as a dark band, up to 7 cm wide, in gray argillite, where soaking on either side of a solution channel has allowed the development of a considerable thickness of biotite. When abundant it appears under the microscope as a solid mat of randomly oriented flakes, but if it constitutes only a small portion of the rock it is usually distributed in isolated or connected patches of aggregates or sometimes as distinct veinlets, see Fig. 2.

Biotite is the first hydrothermal mineral to form in the Hercules vein. All the other minerals are found to occur in veins traversing rock containing biotite.

Andradite: Andradite in small individual crystals occurs primarily in the lower western levels of the mine and is particularly prominent in the Hercules fissure zone, but it is also noted in small amounts in wall rock as much as 15 ft from the main vein.

Quartz: Quartz is present in most of the specimens of vein material. There seems to be no evidence to determine that there were separate distinct periods when quartz was formed, and it is

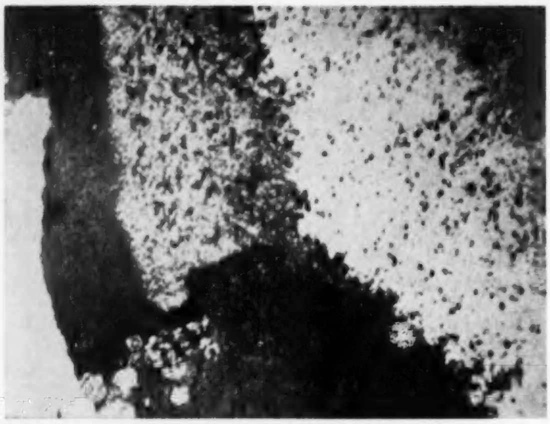

Fig. 2—Biotite from the Hercules mine as revealed under the microscope. Biotite is the first hydrothermal mineral to form in the Hercules vein.

believed that quartz was probably being deposited during all stages of the mineralization.

Grunerite: Grunerite occurs principally in the main Hercules fissure zone in the western part of the vein on the intermediate and lower levels. It is never found in the wall rock for any great distance on either side of the fissure. It occurs in a form which is distinctly fibrous to prismatic with some crystals as much as 1.5 mm long. The color of the mineral is a dark grayish-tan in practically all cases. Grunerite veins cut biotite, andradite, and glassy quartz, but magnetite and sulphides are found to traverse grunerite, thus establishing the relative age of grunerite as premagnetite and presulphide.

Adularia: Adularia was discovered microscopically in two specimens taken from the main Hercules fissure zone between two stoped areas where essentially no prominent sulphide mineralization was present, see Fig. 1.

Chlorite: The chlorite occurring principally in argillite close to the Hercules fissure appears generally green. It is rarely massive, occurring principally as disseminated flakes and patches in otherwise unaltered rock.

Siderite: Light gray to tan siderite is found throughout the mine on the Hercules fissure not only where ore is present but also in many places where ore is absent. It may occur by itself or associated with magnetite and sulphides; thus there seems to be no fixed spatial relationship between the occurrences of ore and siderite.

Also, scattered small crystals of siderite, 0.1 to 0.2 mm, are often found in wall rock adjacent to the main vein. It was either wholly introduced into the wall rock or some of the iron which was introduced into the vein system spread into the wall rock and replaced the calcium in the original calcite of the argillite and converted it to siderite.

Magnetite: Massive to granular magnetite is present in the Hercules fissure throughout the entire mine and nearly always accompanies ore, but it may also occur in places where ore is not present. It seems slightly more abundant in the lower levels.

Sulphides: All the sulphides found during this study, that is, pyrrhotite, pyrite, arsenopyrite, jamesonite, chalcopyrite, galena, and sphalerite, were identified by conventional optical, etch, X-ray, and microchemical methods. It is not necessary to describe the well-known properties of each of these minerals. No chemical analysis was made of the pyrrhotite to determine the precise iron and sulphur ratio, but it was found to be slightly magnetic.*

* Four additional minerals, agentite, cubanite, niccolite, and tetrahedrite, have been reported as occurring in the Hercules by earlier observers (private reports).

Calcite and Late Pyrite: Calcite veins, 1 to 10 cm wide, trending parallel to the main fissure were found cutting through sulphides in several instances. A very few small crystals of pyrite were discovered to occur in vugs and open spaces on the calcite. Also, some veinlets of pyrite, 2 mm wide, were found in sphalerite. These two occurrences of pyrite are believed to have been formed at the same stage of mineralization. It is also believed that they represent the last hydrothermal activity in the Hercules fissure.

From the information obtained by an examination of the specimens of both A. W. Lawson's collection and the present one, it was found that the following spatial relationships, in general, hold true. Biotite, chlorite, magnetite, siderite, quartz, chalcopyrite, galena, and sphalerite are found in the Hercules fissure on practically all levels of the mine. Only biotite, andradite, chlorite and siderite also occur in the wall rock adjacent to the fissure. Andradite and grunerite seem to be more or less restricted to the lower western levels. The distribution of early pyrite and pyrrhotite is one of the most interesting problems found in the mine, see Fig. 1. Pyrrhotite and pyrite are rarely together in the same specimen, and in the lower western levels, pyrrhotite is the exclusive iron sulphide, whereas in the eastern and upper part of the mine, pyrite is essentially the only iron sulphide. There seems to be a narrow transition zone where pyrite and pyrrhotite may occur together, and as far as can be determined, it runs from at least No. 5 level, west of the shaft, to slightly east of the shaft at the 1200 level. Pyrite is also found in the cores of drill holes which encounter the vein considerably below the 1200 level. This suggests that the transition zone between pyrrhotite and pyrite may extend downward steeply to the west from the 1200 level. The meaning of this distribution of the two iron sulphides is not at all clear. The possibility is suggested that the western part of the orebody was deposited at a somewhat higher temperature, thus pyrrhotite, being considered a higher temperature mineral, was formed. Arsenopyrite and jamesonite are found only on the edges of stopes in the upper eastern portions of the mine. Adularia occurs on the 800 and 1000 levels in a completely barren section of the Hercules fissure, see Fig. 1.

In a review of the mineralization of the Hercules fissure, disregarding quartz, which seems to have formed continuously throughout the mineralizing period, a very interesting and perhaps significant grouping of the minerals is possible according to the time or period of development, and at least five or perhaps six distinct stages could be postulated as follows, see Fig. 3:

Stage 1. Silicate: In the first stage, the minerals biotite, andradite, grunerite, adularia, and chlorite were formed. During this period much Fe_2O_3, FeO, and SiO_2 were introduced along with small amounts of MgO, Al_2O_3, and a very little K_2O and CaO. Whether or not some or all of these materials are from a magmatic source cannot be positively determined, since the unaltered wall rock contains all of these substances in various amounts and could have

possibly contributed some constituents to the primary solutions as they traversed the rock.

Stage 2. Carbonate (Siderite): The second stage may be distinguished from Stage 1 on the basis of the different nature of the radical. The concentration of FeO and/or Fe_2O_3 in the introduced solutions continued to be high, but in this instance CO_2 or possibly CO were also available and the mineral siderite was deposited.

Stage 3. Oxide (Magnetite): This stage could be separated from the second on the basis that the radical is different. Here it may be supposed that Fe_2O_3 and FeO were the only materials deposited. Of course, it may be reasoned that Stage 3 (magnetite) and Stage 2 (siderite) might represent the same stage but that during Stage 3 there was an excess supply of iron over CO_2 or CO to make siderite, and magnetite developed as a result. The nature of the distribution of these two minerals, however, might serve to refute this idea to some extent since siderite is frequently found in many areas by itself, and often magnetite occurs without being associated with siderite.

Stage 4. Sulphide: In this most important stage the sulphides pyrrhotite, pyrite, chalcopyrite, arsenopyrite, jamesonite, galena, and sphalerite were formed. This mineral assemblage indicates that sulphur was a profuse constituent in the solutions at this time and that Fe, Pb, and Zn were abundant together with a little Cu, As, and Sb. Up to this stage, Fe was present constantly in the depositing solutions, but the supply was apparently discontinued during the development of the last three minerals, jamesonite, galena, and sphalerite.

On this basis, the sulphide stage could be separated into two separate substages, one where iron was deposited and the other where iron was not deposited. The paragenetic relations between the galena and sphalerite stage and the earlier sulphides, excepting jamesonite and arsenopyrite, quite clearly indicate that there is a distinct separation in time of deposition between the two stages. It is therefore considered reasonable to separate the sulphide stage into two sub-stages.

Stages 5 and 6. Calcite and Pyrite: These last two stages are distinctly later than the earlier stages as shown by both structural and compositional evidence. It could be argued that the deposition of calcite in crosscutting late veins represents a supergene action, and there is really no reason to refute this, except that the presence of pyrite crystals in vugs in the calcite would not be so easily explained by the same process. Pyrite could form from supergene waters if they had been in contact with a great deal of sulphide material, resulting in a reducing environment. However, the hypothesis that the calcite and small amounts of pyrite formed during late phases of hydrothermal activity seems to be the most reasonable. The possibility that the calcite was supergene and that the later pyrite was deposited by a weak resurgence of hydrothermal activity seems remote.

Hydrothermal Alteration

If hydrothermal alteration is thought of in the conventional sense, i.e., mineralogical changes in the wall rock near an orebody, there is a surprisingly small amount of it in the Hercules area in relation to the size of the deposit as contrasted with that found at Butte,[3] Santa Rita,[4] Tintic,[5] Bingham,[6] and other districts where this feature has been studied. As far as can be observed, the wall rock adjacent to the

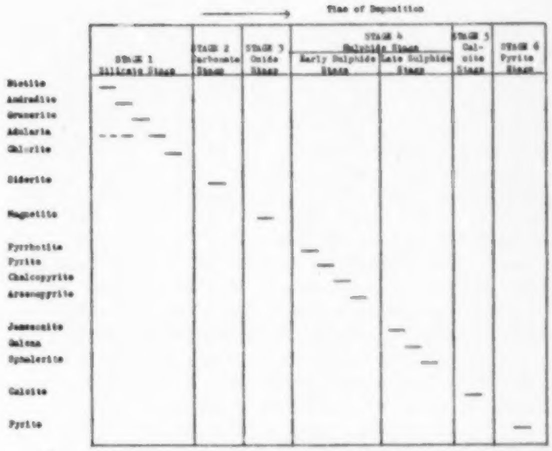

Fig. 3—Paragenesis of hydrothermal mineral development in the Hercules vein.

Hercules fissure has been affected by the development of biotite, andradite, and chlorite for only a short distance, 15 ft maximum, on each side of the mineralized fissure and this condition is found only in the lower western levels. Near heavy sulphide mineralization on the lower eastern levels, many instances were noted where essentially fresh rock was adjacent to the sulphides, and on the upper levels this condition definitely prevailed. Hydrothermal siderite was found in small amounts within the wall rock for a distance of a few feet away from the fissure and adularia is present only in the *barren* sections of the Hercules fissure proper.

From the highest level of the mine to the deepest, biotite, chlorite, and siderite are present in the wall rock at various points within and very near the main fissure. These minerals are not always associated with the *ore* and may occur in barren zones. Ore is also often seen without appreciable green sericite or chlorite associated with it.

Four possible reasons are presented to explain the lack of widespread hydrothermal effects in the Hercules. 1—The channels within the fissure were sufficiently open at the time of early solution movement to allow them free and easy movement up through the fissure, and pressures were not high enough to force solutions into the wall rock. 2—The wall rock was not sufficiently fractured or porous to allow much solution penetration into it even though pressures may have been high. 3—The supply or amount of altering solution was so limited that a large area could not be affected. 4—The time that the existing altering solutions were present was so short that diffusion into the wall rock was limited.

The physical and chemical environments under which biotite and chlorite form are not well known, and an hypothesis regarding the pH of the altering solutions forming these two minerals is therefore not possible. Siderite is reasoned to form under alkaline conditions. Sericite is known to form under acid conditions at high temperatures, above 350°C, but at lower temperatures, below 350°C, it forms under alkaline conditions.[7] If biotite forms under conditions similar to sericite, interpolation of the temperature and pH of the solutions is possible with the assumption that the pH of the solutions did not appreciably change during the first (silicate) and second (siderite) stages; then in both stages the solutions were alkaline and the temperatures were low, below

350°C. This conclusion, which is necessarily based on an assumption, brings forcefully to the student of hydrothermal alteration that more laboratory data are very much needed regarding the physical-chemical conditions under which minerals form, so that even such a restricted problem as the pH of hydrothermal solutions may be better interpreted.

The restricted nature of the green sericitic and sideritic alteration in the Hercules mine makes the use of hydrothermal alteration poor as a guide in exploration. These alteration minerals do not form a much larger target than the orebody itself and in some places the orebody is present where these alteration minerals are entirely absent. It may be stated, however, that if in crosscutting or drifting any of these minerals were found in considerable amounts without associated ore, it would be presumed to be an encouraging situation.

The widespread sericitic alteration of the rocks in the Coeur d'Alene region has been known for some time and is locally referred to as *bleaching*. Hoyt S. Gale first recognized this alteration, but he noted it only in private reports. Shenon and McConnel[8] recorded their observations on the sericitic type of alteration in 1939. It is understood that a paper by Thomas Mitchem as a Ph. D. thesis from Columbia University dealing in detail with this alteration is in press. A detailed account of it is therefore not appropriate here, but the relation to the overall district conditions may be of some interest. Quite a number of sericitic type of rocks were collected and studied. All the formations exposed in the Coeur d'Alene district have at some place or another been partially or completely altered to sericite. A description of the field occurrence of this alteration may best be quoted from Shenon and McConnel where they mention that within the district "several well defined zones of hydrothermal alteration, as much as one-half mile wide, are found. . . . The rocks in the zones regardless of their original color or composition are sericitized and are altered in color from gray or purple to some shade of green . . . . In general, the argilaceous rocks have been most completely altered but where the alteration processes were intense, massive quartzites, as well as argillites, have been altered to sericitic rock." It is of particular interest that no alteration of the above type is found anywhere in the vicinity of the Hercules fissure. The presumption is, then, that although the sericitic type of alteration is associated with ore in the district in a very broad general way, oreshoots do not always follow it and bleaching therefore cannot be regarded as a positive guide to ore.

Acknowledgments

The authors wish to offer thanks and appreciation to Henry L. Day, President of Day Mines, Inc., who gave his full support and encouragement to this work and offered valuable advice and information during the course of the investigation.

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Starches and Starch Products as Depressants In Amine Flotation of Iron Ore

by C. S. Chang, S. R. B. Cooke, and R. O. Huch

IN the flotation of iron ores laurylamine derivatives have been used for considerable time.[1,2] To effect satisfactory separation of the gangue, predominantly silica, from the iron oxide minerals, the addition of specific depressants for the iron oxides has been found necessary. Starches and starch products have been used for this purpose.[3] There is, however, very little published information on the effects of these materials and other variables on this process. In some cases it has been found that prior acid scrubbing and desliming are essential,[4] and depending upon the efficiency of the subsequent washing step, there will be accompanying changes in pH.

It was the object of this investigation to test and observe the effects of the above factor as well as to examine and compare the action of various starches and starch products.

C. S. CHANG, Junior Member AIME, is Research Associate, School of Mines and Metallurgy, University of Minnesota. S. R. B. COOKE, Member AIME, is Professor of Metallurgy and Mineral Dressing, University of Minnesota. R. O. HUCH, Student Associate AIME, formerly Teaching Assistant, School of Mines and Metallurgy, University of Minnesota, is now with the Galigher Co., Salt Lake City.

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Ore Preparation

The ore used in this experiment was a wash-ore tailing obtained from the western Mesabi range. Microscopic examination and x-ray analysis of the ore showed it to consist of hematite, goethite, and quartz. Physical properties of the iron minerals ranged from hard and crystalline to earthy and ocherous. The quartz grains were discolored either because of iron-oxide inclusions or because of a surface coating of iron oxide. The ore assayed 27.52

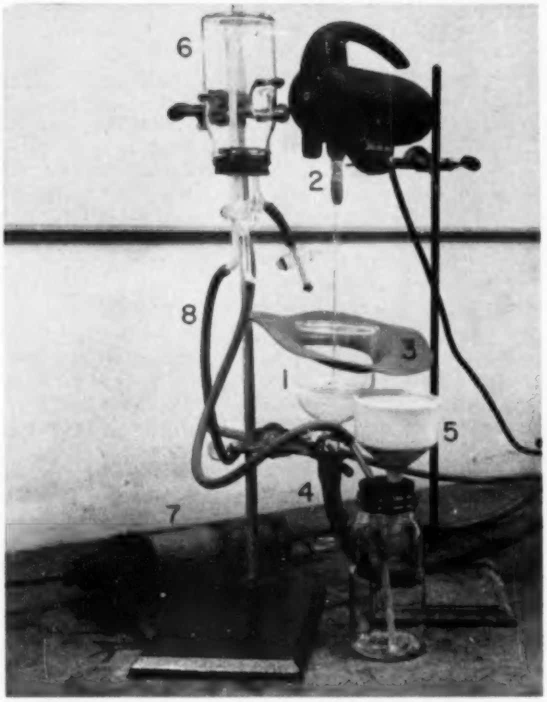

Fig. 1—The flotation cell with auxiliary equipment. (1) Buechner fritted glass funnel, (2) stirrer with pyrex stirring rod, (3) rubber sleeve, (4) air inlet, (5) Buechner funnel, (6) solution reservoir, (7) air filter, and (8) vacuum line.

pct iron and 57.11 pct silica, and, as received, had been screened through 20 mesh.

To prevent overgrinding, the −100 mesh material was first removed by screening. The +100 portion was ground in a Denver laboratory rod mill until all of it passed through 100 mesh. The ore was then deslimed at roughly 20 microns in a 3-ft Denver bowl thickener in closed circuit with itself.

Acid scrubbing was accomplished by placing 1 kg of deslimed ore in a laboratory Fagergren cell, enough water to bring the pulp level to the top of the baffle plate, and 1 ml of concentrated sulphuric acid, equivalent to 3.6 lb per ton of ore. The pulp at this stage had a pH of 2.1. (All reagent additions used in the paper refer to the short ton.) The pulp was agitated for 5 min. Because of the large quantity of fresh slime material produced during the acid scrubbing, the ore was again deslimed, by sedimentation, until the supernatant liquid became clear. This also removed substantially all the sulphuric acid. The ore was given a rinse with demineralized water before it was dried. It was then thoroughly mixed in a box-type tumbler, split with a Jones splitter, and stored in glass bottles. The flotation feed represented approximately 80 pct of the original ore. A screen analysis is given in Table I.

The specific surface of the prepared ore, determined by the krypton gas-adsorption method,[5] was 1.82 m^2 per gm. The material was fractionated in acetylene tetrabromide at specific gravity 2.96. The float, 47.9 pct by weight of the material, had a specific surface of 0.22 m^2 per g and was essentially quartz. The sink product carried practically all the iron minerals as well as some locked quartz. By calculation, the sink product had a specific surface of 3.28 m^2 per g, equivalent to 94 pct of the total surface of the flotation feed.

To avoid vigorous agitation, which always resulted in the production of fresh slimes, a test cell, fundamentally of pneumatic type, was devised. This cell consisted of a 350-ml capacity Buechner fritted glass funnel with medium porosity frit. Air was admitted through the bottom of the cell and controlled by a needle valve. Admission of air alone did not give sufficient agitation to keep all the material in suspension; hence supplemental mild agitation, provided by a motor-driven glass stirring rod, was used in the cell. To facilitate the collection of the froth, a rubber sleeve was fitted to the neck of the cell.

Table I. Screen Analysis of Flotation Feed

Screen Size, Mesh	Wt, Pct	Iron, Pct
−100 +150	37.29	29.23
−150 +200	40.28	29.62
−200 +270	17.45	41.48
−270 +400	3.63	61.43
−400	1.35	66.65
	100.00	33.20

The complete assemblage is shown in Fig. 1. The froth flows from the cell into a Buechner funnel where the froth is filtered and the filtrate transferred to the solution reservoir by suction. This solution is then available for re-introduction to the cell when desired and eliminates the necessity of adding water during a test.[a]

To the cell were added 50 g of ore and 200 ml of solution containing those starches and starch products required for the test. This mixture was conditioned, with agitation only, for 2 min, after which the laurylamine acetate collector was added. This was followed by an additional 30 sec of conditioning. The air was then admitted to the cell and the froth was removed until it was barren of mineral.

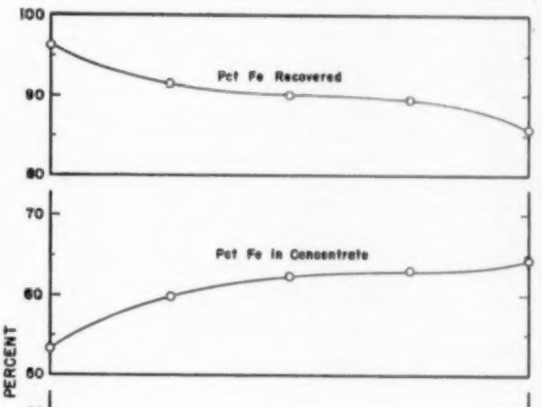

Fig. 2—Effect of collector addition with 0.03 lb Gum 3502 per ton.

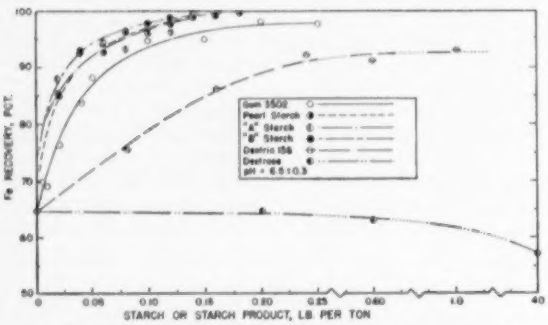

Fig. 3—Effect of starch addition on percent iron recovered. Laurylamine acetate addition at 0.26 lb per ton.

This removal required 1 to 3 min depending on the froth characteristics. The froth contained most of the silica, and the iron concentrate remained in the cell. Assays were made on these two products.

At the end of each test the pH of the pulp liquid was measured with a Beckman Model G pH meter. In all cases thorough washing and desliming followed the acid scrubbing, and the pulp reached an equilibrium pH of 6.5 ± 0.3. All tests in which pH was not regulated were made within this range.

Before being used in any subsequent tests, the flotation cell was thoroughly washed with hot water and rinsed with demineralized water.

Collector: The laurylamine acetate, 99.9 pct pure, was supplied by the Research Division of Armour and Co. For addition to the cell, a freshly prepared 0.1 pct solution was used.

Depressants: All starches and starch products tested, except the dextrose, were obtained from Corn Products Refining Co., New York. They are described below.

Gum 3502 is a water-soluble, partially degraded starch. The material is readily soluble in hot water.

Pearl starch is corn starch which has been prepared with a minimum of alteration. It is essentially insoluble in water at room temperature. The solution added for the test was prepared by digesting it in water in an autoclave at 120°C for 1 hr.

A and *B* starches are fractions of corn starch. The *A* fraction, which is quite soluble in water, consists mainly of amylose, i.e., unbranched and long-chain starch molecules. The partially water-soluble *B* fraction consists primarily of amylopectin, i.e., branched starch molecules. The preparation of solutions of these starches was similar to that for pearl starch. However, before treatment in an autoclave, it was found necessary first to disperse them in benzene and later to remove this by adding hot water and boiling.

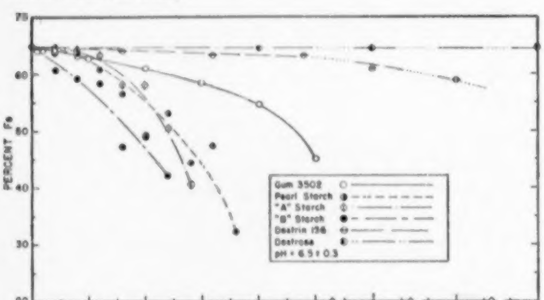

Fig. 4—Effect of starch addition on percent iron in concentrate. Laurylamine acetate addition at 0.26 lb per ton.

Dextrin 156, a decomposition product obtained by dry heating of starch, is wholly water-soluble.

Dextrose is a monosaccharide resulting from complete degradation of starch. The material used was of C.P. reagent grade.

All the starches and starch products were added to the flotation cell as 0.1 pct solutions.

Other Reagents: The pH regulators, sodium hydroxide and hydrochloric acid, were of analytical reagent grade. Demineralized water, containing less than 0.1 ppm of salts as NaCl, was used in the preparation of all solutions and for all test work.

Effects of Collector Addition: It was necessary to first decide on a collector concentration at which the tests should be run. Lindroos[4] found that for the same ore a fairly satisfactory separation was obtained with 0.03 lb of Gum 3502 per ton. A series of tests was therefore made by using this same gum concentration and varying the quantity of collector. The results are shown in Fig. 2.

It can be seen that the iron recovery decreases and the iron content of the concentrate increases with increasing collector addition. In fact, preliminary tests showed that the whole ore could be floated if an exceedingly large quantity of collector were used. However, when excess starch was added, the ore was completely depressed and it could not be made to respond to flotation again even with a large addition of collector.

At a collector addition of 0.26 lb per ton, a good grade of concentrate was obtained assaying 63 pct iron with only 6 pct silica representing a fairly high recovery of 89 pct. At lower collector additions, fair results were obtained, but the froth possessed poor characteristics and it was necessary to add some frother to remove completely all the floatable minerals. Since introduction of an additional variable was undesirable, the value of 0.26 lb of laurylamine acetate per ton was chosen for all subsequent tests.

Effects of Various Starches and Starch Products: The starches and related products used in these tests have already been listed. The amount of collector was kept at 0.26 lb per ton while the starch addition was varied. The results are given in Figs. 3, 4, and 5.

In interpreting the results, it will be of assistance to remember that the flotation of the iron ore at a pH of 6.5 with no reagent addition other than 0.26 lb of laurylamine acetate per ton gave an iron recovery of 65 pct in a concentrate assaying 64.6 pct iron and 3.0 pct silica. The effect of an ideally selective depressant for iron minerals would be to maintain a grade of concentrate reasonably close to that given above, with the overall iron recovery simultaneously approaching 100 pct. No such depressant is known, but the relative efficacy of the reagents tested as iron oxide depressants is measured by the positions of their respective curves in the three figures. It should also be remembered that technologically and economically the iron concentrate may contain as low as about 61 pct iron and about 8.5 pct silica. Iron recovery, on the other hand, depends entirely upon economic considerations which need not be discussed here.

In Fig. 3, the recovery of the iron in the concentrates is plotted against the iron depressant added. Fig. 4 shows the relationship between the grade of concentrate, expressed as percent iron, and the amount of depressant added, and Fig. 5 shows the iron content of the tailings, plotted against the amount of starches or starch products added.

In these graphs it will be seen that the general trend, with the increasing depressant additions, is

toward a higher recovery of iron (Fig. 3), a lower grade of iron concentrate (Fig. 4), and less iron reporting in the froth (Fig. 5). This is to be expected, since, with the increasing starch additions, a greater depressing effect is exerted, not only toward the iron minerals, but also toward the quartz grains. At the low depressant additions, there is evidently insufficient starch to coat all of the iron minerals present. As a result, some of these minerals are sufficiently coated with the collector to be floated.

It is obvious from all these figures that the *B*-fraction starch is the least selective depressant. This is indicated by the rapid decrease in the grade of iron concentrate and by the steeply rising iron recovery curve with increase of reagent. It is concluded from these results that of any reagents tested the *B*-fraction starch is the least selective depressant at a pH of about 6.5.

The effects of Pearl starch, *A*-fraction starch, and Gum 3502 are similar to each other. The grade of concentrate produced by them is superior to that given by the *B*-fraction, although total iron recoveries are approximately the same with the exception of Gum 3502, which gives slightly less recovery than the others.

Dextrin permits production of a very good grade of concentrate, but the percent iron recovery is less than with any other starches or starch products but dextrose, which has no effect on flotation operation.

Both Pearl starch and the *B*-fraction starch contain water-insoluble constituents, and these could possibly have an effect on flotation. To clarify this point, the starch solutions were centrifuged to remove the insoluble materials. Flotation tests using these *cleaned* starches gave results no different from those using the whole starch products.

Effects of pH: In the investigation of the effects of pH, collector and starch concentrations were kept constant while the pH was varied from 3.9 to 11.2. The collector addition was maintained at 0.26 lb per ton with Gum 3502 at 0.10 lb per ton in one set of tests and Pearl starch at 0.06 lb per ton in another. A series of tests was also made with no depressant used. The results are shown in Figs. 6 to 8.

There is a decrease in the iron recovery in near-neutral pulps, Fig. 6. This decrease is minor in the presence of either starch or gum but is very pronounced when neither is used. A corresponding increase in percent iron in the concentrate, Fig. 7, is shown in the same region for all of them, with the grade of concentrate dropping off at high and low pH. At the concentration of laurylamine acetate employed, a precipitate, presumably laurylamine hydroxide, begins to form in pulps of higher pH than 9. Since this is the case, the reason for the poor grade of the concentrate at high pH, with resulting high recovery, is probably that insufficient laurylamine ion is available for collection and therefore more silica and iron minerals remain in the cell. The low grade of iron concentrates obtained at low pH may be attributed to insufficient adsorption of the collector ion on the minerals. Hydrogen ion, in acid pulps, may compete strongly with the laurylamine ion for occupancy on the mineral surfaces.

Particle Size in Flotation Products: In an attempt to explain the appearance of quartz in the concentrate and iron minerals in the froth, screen analyses were made on flotation products of two tests, one in which 0.03 lb Gum 3502 per ton was used and one in which 0.04 lb Pearl starch per ton was used.

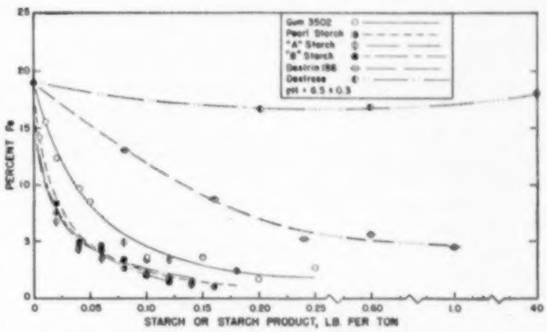

Fig. 5—Effect of starch addition on percent iron in froth. Laurylamine acetate addition at 0.26 lb per ton.

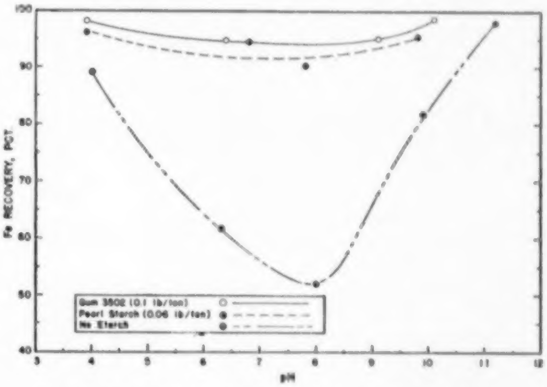

Fig. 6—Effect of pH on percent iron recovered, with no starch, with Gum 3502, and with Pearl starch. Laurylamine acetate addition at 0.26 lb per ton.

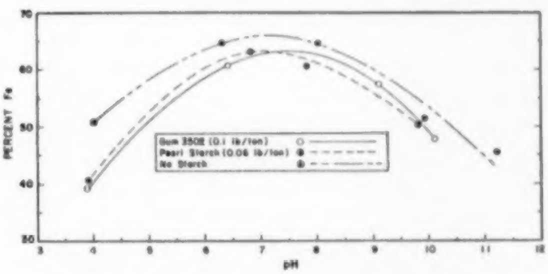

Fig. 7—Effect of pH on percent iron in concentrate, with no starch, with Gum 3502, and with Pearl starch. Laurylamine acetate addition at 0.26 lb per ton.

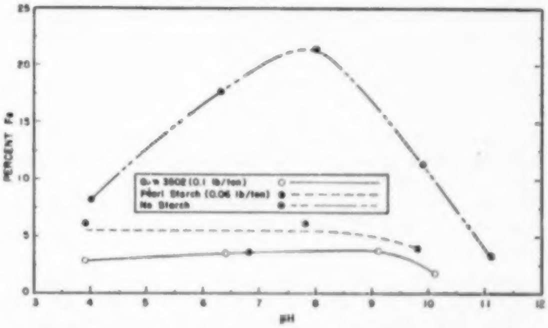

Fig. 8—Effect of pH on percent iron in froth, with no starch, with Gum 3502, and with Pearl starch. Laurylamine acetate addition at 0.26 lb per ton.

Assays were made on the screened products and the results are given in Tables II and III.

These tables show that most of the quartz in the concentrate is contained in the coarsest screen fractions. Microscopic examination of these fractions showed that most of the quartz appeared as free grains which apparently failed to respond to collection. In the froth product, the percent iron rises very sharply as the particle size decreases, indicating that a large part of the iron consists of free oxide particles which presumably are carried mechanically into the froth. Microscopic examination

Table II. Screen Analyses of Flotation Products with Gum 3502, 0.03 Lb per Ton

Screen Size, Mesh	Wt, Pct	Iron, Pct
Concentrate, 46.7 pct by weight		
−100 +150	37.18	58.95
−150 +200	36.86	63.54
−200 +270	19.40	65.89
−270	6.56	67.02
	100.0	62.55
Froth product, 53.3 pct by weight		
−100 +150	37.48	2.74
−150 +200	43.34	4.35
−200 +270	15.78	15.00
−270	3.49	55.97
	100.00	7.18

Table III. Screen Analyses of Flotation Products with Pearl Starch, 0.04 Lb per Ton

Screen Size, Mesh	Wt, Pct	Iron, Pct
Concentrate, 47.6 pct by weight		
−100 +150	35.57	59.21
−150 +200	36.13	63.07
−200 +270	23.91	65.49
−270	4.39	65.81
	100.00	62.41
Froth product, 52.4 pct by weight		
−100 +150	39.68	3.39
−150 +200	43.46	3.95
−200 +270	14.92	9.11
−270	1.94	51.78
	100.00	5.43

of the coarse fractions of the froth products showed that most of the iron occurred as locked grains.

During the tests, intense flocculation of the quartz occurred after the addition of the collector. It is therefore possible that most of the iron mineral particles carried into the froth were those trapped during flocculation. The possibly beneficial results of adding a dispersant were not studied at this time.

To obtain an effective separation of the iron oxides from the quartz by cationic flotation, it is necessary to maintain the iron oxide surface in a hydrophilic condition and that of the quartz hydrophobic. If laurylamine acetate alone is added, the quartz will be floated, but unfortunately, because of their capability of adsorbing the collector, a considerable quantity of iron oxides will appear in the froth. The function of the starch or of related substances as an additive is to prevent, or at least to minimize, the adsorption of the collector on the iron mineral surfaces so that a higher degree of selectivity may be realized.

Cooke and co-workers[7] have shown that starches selectively coat hematite in preference to quartz. The mechanism by which the starch inhibits collector coating is not clearly known. However, because of the presence of large numbers of OH groups in the starch molecule, mineral surfaces coated with starch should be hydrophilic.

To evaluate the selectivity and the effectiveness of the starches and starch products tested as iron oxide depressants, it is necessary to set a specification on both the grade of the iron concentrate produced and on the iron recovery. The quantities of various starches and starch products to produce iron concentrates containing 8.5 and 12.0 pct silica respectively with iron recovery greater than 90 pct were determined with the aid of Figs. 3 and 4 and the silica assay of the iron concentrates.

Table IV. Quantity of Starch to Produce Specified Grade Fe Concentrates at Fe Recoveries Greater than 90 Pct

Starch		Grade of Fe Conc.		
Type	Lbs per Ton	SiO_2, Pct	Fe, Pct	Fe Recovery, Pct
Pearl	0.055	8.5	61.5	92.5
A	0.075	8.5	60.5	94.5
Gum 3502	0.105	8.5	60.5	93.5
Dextrin 156	0.650	8.5	60.0	92.5
B	0.050	12.0	57.5	94.0
Pearl	0.075	12.0	59.0	95.0
A	0.090	12.0	58.0	95.5
Gum 3502	0.150	12.0	58.0	96.0
Dextrin 156	1.020	12.0	58.0	93.0

Table IV shows that Pearl starch, *A*-fraction starch, Gum 3502, and Dextrin 156 can produce iron concentrate containing 8.5 pct quartz with an iron recovery ranging from 92.5 to 94.5 pct. These substances can therefore be classified as selective iron oxide depressants. *B*-fraction starch is not included since it produces inferior grade iron concentrate. If the effectiveness of the starches and starch products as selective depressants is based on the quantity of their addition to bring about the specified concentration, then Pearl starch is the most effective depressant tested, followed respectively by *A*-fraction starch, Gum 3502, and Dextrin 156.

Summary and Conclusions

1—The following starches and starch products, in order of decreasing metallurgical effectiveness, are selective depressants for iron oxide minerals: Pearl starch, *A*-fraction starch, Gum 3502, and Dextrin 156.

2—*B*-fraction starch gives poor selectivity as an iron oxide depressant and dextrose has no effect, beneficial or otherwise.

3—The optimum pH for flotation at laurylamine acetate addition of 0.26 lb per ton ranges from 6 to 8.

Acknowledgments

The authors express thanks for the assistance of Henry H. Wade of the Mines Experiment Station, University of Minnesota, Vernon E. Bye and associates of the same institution, the Corn Products Refining Co., and Armour and Co.

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Mining Branch Technical Program Preparations Near Completion; Annual Meeting Dinner-Smoker to Feature Latin Quarter Show

Big news for the Dinner-Smoker scheduled for the Annual Meeting Feb. 15 to 18 is that the entire Latin Quarter show has been engaged. One of the world's most famous night clubs, its shows have been termed fabulous year after year. Its talent has been some of the best on Broadway.

News of the show is another indication that the 1954 meeting will be one of the most successful, entertaining, and informative in the history of the event. Committees are well advanced in arrangements for Woman's Auxiliary activities, technical sessions, and the round of luncheons and dinners.

For the ladies, the traditional coffee get-togethers, luncheons, and fashion shows are being finalized. The Annual Meeting takes place at the peak of the New York theatrical season. Ladies desiring to see specific plays should arrange in advance for tickets with theaters. Among current productions are; *Dial M For Murder, My Three Angels, Picnic, South Pacific, The King and I, The Seven Year Itch, Wonderful Town,* and *Tea and Sympathy.*

Technical Session Plans

Mining Branch plans for technical sessions are going ahead rapidly. An outstanding feature of the Minerals Beneficiation Div. and the Minerals Industry Educations Div. is a joint session with representatives from the Humble Oil Co. and Harvard Business School as the main attraction. Another MBD session, on concentration, will be built around a highly interesting group of papers. Among the papers for the session are: *Flotation Theory: Molecular Interactions Between Frothers and Collectors at Solid-Liquid-Air Interfaces,* J. Leja and J. H. Schulman; *Starches and Starch Products in Amine Flotation of Iron Ore,* C. S. Chang, S. R. B. Cooke, and R. Huch; *Milling Kentucky Fluorspar Tailings,* LaMont West and R. R. Walden; *The Beneficiation of Cassiterite,* R. C. Meaders; *Progress in the Flotation of Cassiterite,* T. F. Mitchell; *Manganese Upgrading at Three Kids, Nevada,* S. J. McCarroll; *Mineral Flotation with Ultrasonically Emulsified Reagents,* S. C. Sun, L. Y. Tu, and E. Ackerman; *Laboratory and Industrial Flotation of Oxidized Zinc Ores with Fatty Amines,* Maurice Rey and P. Raffinot; *Comparison of Ferrosilicon Recovery,* G. A. Komadina.

The Crushing and Grinding session committee has announced four papers. They include: *Free Radicals and Chemical Reaction in Comminution,* A. M. Gaudin; *Analysis of Variables in Rod Milling,* Will Mitchell, Jr.; *Spiral Lifters in Ball Mills,* E. J. Klovers; and *Screen Sizing Sub Micron Particles,* R. J. Charles.

Several interesting papers have been scheduled for the Materials Handling session. G. H. Wilson will present *Application of Closed-Circuit TV to Conveyor and Mining Operations.* Other papers on tap are: *Feeders in Beneficiation Plants,* O. W. Walvoord; *Control of Fire Hazards for Conveyor Belting in Mines,* E. R. Traxler; and *Bin Design to Minimize Size Segregation,* S. D. Michaelson and E. B. Nelson.

Operating Controls

Papers to be heard at the Operating Control session are: *Servo-Technique in Process Control,* N. H. Dorenfeld; *Inertial Flowmeters for Mass Flow Measurement,* W. A. Jones; *A New Method of Density Control,* J. W. O'Hara; *A Quick Estimation of Mill Product Purity by Transparency Measurements,* S. C. Sun, H. M. Fisher, and R. E. Snow; and *Factors Affecting the Accuracy of Conveyor Scales,* R. O. Bradley.

Under Pyrolysis and Agglomeration, papers listed are: *FluoSolids Roasting of Pyrite Telluride Flotation Concentrates at Golden Cycle Corp.'s Carlton Mill,* H. R. Keil; *Solid State Bonding in Iron Ore Pellets,* S. R. B. Cooke; *FluoSolids Conversion of Iron Ores to Magnetites,* R. J. Priestley; *Sinter is What You Make It,* E. H. Rose and D. J. Reed; and *Looking at Sinter Testing,* E. H. Kinelski, H. A. Morrissey, and R. E. Powers.

The Solids-Fluids Separation session announced five papers which include: *A Practical Approach to Selection of Filter Media,* Frank Weems; *The Drying of Ore and Concentrates,* Byron Marquis and Harlow J. Reed; *Laboratory Techniques for Dust Collection,* Frank Stephens; *Continuous Pressure Filtration;* and *Collection of Fumes from Ferro-Silicon Electric Furnace Operations,* Leslie Silverman and R. A. Davidson.

MBD has scheduled a symposium with the following papers slated for presentation: *The Metallurgical Disc Filter with Mechanical Agitation,* Frank Weems; *High-Speed Rod Milling,* Fred D. DeVaney; and *13x13-ft Ball Mills at White Pine,* D. P. Hale, Jr.

The famous Scotch Breakfast will again be held in the Cafe Rouge of the Statler Hotel. Many notables are expected to attend, according to the Committee. The MBD Luncheon is also well into the planning stage.

Tentative List of Papers Indicates Unusually Fine Sessions

MBD Sets Joint Session with EMD

Papers for the Joint EMD and MBD Solution and Precipitation session thus far scheduled are: *Electrolytic Production of Hydrometallurgical Reagents for Processing Manganese Ores; Specific Data on Ion-Exchange in the Metallurgical Industry*, A. B. Mindler; *Operations of the Sherritt Gordon Pilot Plant*, F. A. Forward; *Continuous Ion-Exchange in Metallurgy*, E. A. Swinton and D. E. Weiss; *Data on Continuous Leaching*, W. B. Hall; and *A Practical Determination of Residence Time and Short Circuiting of Dry Solids or Solids in Slurries in Continuous Systems*, R. B. Coleman and J. D. Moore.

Geology Subdivision

The Geology Subdivision's Iron and Ferro-Alloy session is scheduled to contain such papers as: *Preliminary Report on Replacement and Alteration at the Soudan Iron Mines, Minnesota*, G. M. Schwartz and I. L. Reid; and *Lateritic Nickel-Cobalt Deposits at Moa, Oriente, Cuba*, R. V. Colligan. Porphyry Copper Deposits and other Disseminated Deposits will be covered with: *Certain Structural Features of Porphyry Copper Deposits in Western and Southwestern U. S.*, E. N. Pennebaker; *Structural Control of the Globe-Miami District, Arizona*, N. P. Peterson; *Structure and Mineralization, Silver Bell, Arizona*, K. V. Richard and Harold Courtright; *Hydrothermal Alteration at the Climax Molybdenite Deposit, Colorado*, J. W. Vanderwilt and R. U. King.

Base Metals

Under the topic of Base Metal Deposits, papers expected are: *Productive Deposits of the Metaline District*, H. F. Mills; *General Structural Relations of the Upper Mississippi Valley Zinc-Lead District*, Allen V. Heyl; and *Structural and Stratigraphic Control in the Shasta Copper-Zinc District, California*, A. R. Kinkel, Jr.

Four papers are set for the Radioactive Material category. They are: *Investigations of Uranium-Bearing Deposits of the Boulder Batholith, Montana*, E. E. Thurlow and L. D. Jarrard; *Progress Report on the Origin of Uranium Deposits*, D. L. Everhart; *Edith River Uranium Deposits*, N. H. Fisher; and *Uranium Exploration, Rum Jungle Province, Australia*, N. H. Fisher and C. J. Sullivan.

Other papers to be heard are: *Cylindrical Color Photography of Bore Holes*, E. B. Burwell, Jr., and R. H. Nesbitt; *Geology of the Cold Spring Tungsten Mine, Boulder City, Colo.*, G. C. Ridland; and *The Magnetic Attraction of Stacked Drill Rods*, John L. Baum.

Geophysics Subdivision

Among papers forthcoming from Geophysics Subdivision sessions, registrants can look forward to: *Depth Determination by Electrical Resistivity*, Harold Mooney; *The Gish-Rooney Commutator—Some Details of Its Construction and Use*, Shelley Krasnow; *A Detailed Electrical Resistivity Survey for Commercial Gravels in the Meramec River Flood Plain*, Rollyn P. Jacobson; *Electrical Methods of Prospecting*, P. C. Wuenschel; *Method of Mapping Shallow, Lateral Stratigraphic Variations with a Refraction Seismograph for Mining Purposes*, R. M. Tripp and T. R. Shugart; *Geophysical Prospecting in New Brunswick, Canada*, S. H. Ward and Harry Seigel.

Comparison of Geochemical, Geological, and Geophysical Prospecting Methods at the Malachite Mine, Jefferson County, Colorado, Lyman C. Huff; *Direct Oil Finding Technique*, Leo Horvitz; *The Earth Sciences Program of the National Science Foundation*, H. Kirk Stephenson; *An Electromagnetic Method for Use in Deep Drill Holes*, S. H. Ward; *Importance of Low Level Recording in Airborne Magnetic Surveys*, Hans Lundberg; *Near Surface Velocity Problems—Williston Basin*, Richard H. Hopkins; *Geophysical Aspects of Uranium Prospecting*, D. F. Coolbaugh; and *Shallow Depth Seismic Refraction Exploration*, R. Burton Rose.

Industrial Minerals Div.

The Industrial Waters section of the Industrial Minerals Program is scheduling such papers as: *Modern Techniques of Water Well Drilling and Development of Ground Water Supplies*, O. F. Jensen, Jr.; *Relation of Ground Water to the Mining Industries In Arizona with Considerations of Legal Aspects*, Elmer D. Hershey; *Water Supply Problem of National Petrochemicals Corp.*, R. D. Wilson; *Mining Drainage Problems in the Anthracite Regions of Pennsylvania*, S. H. Ash; *Forecasting Water Conditions in the Cayia Mine and Results, Crystal Falls, Mich.*, Peter P. Ribotto; *Mining-Hydrology Problems in the Birmingham Red Iron Ore District*, Thomas A. Simpson; *Pumping Test Determines Water Conditions at Fad Shaft, Eureka, Nev.*, Wilbur T. Stuart; *Determination and Elimination of Recirculation of Surface Water of Jefferson City, Tenn.*, R. M. Richardson; and *Ground Water Control in Underground Mining*, R. C. Mahon.

Finalized Program Expected in January

The Fluorspar Symposium will have papers on: *Fluorspar Requirements*, James A. Barr, Sr.; *Fluorspar Supplies in the U. S.*, A. H. Sutton; *Fluorspar Supplies in Mexico*, W. P. Hewitt; *Fluorspar Supplies in Europe*, H. R. Hose; *Concentration of Fluorspar at Rosiclare, Ill.*, C. O. Anderson; and *Phosphate Rock as an Economic Source of Fluorine*, K. D. Jacob and W. L. Hill.

Papers planned for the Cement, Lime, and Gypsum session include: *Latest Practice in Burning Lime and Cement in Europe*, O. G. Lellep; *Use of Refractories in Improving Capacity and Efficiency of Rotary Kilns*, W. F. Rochow and W. C. Burke; *The Suspension Pre-Heater*, G. K. Englehart; *Use of Cyclones for Slurry-Classification*, C. C. Van Zandt; and *Manpower as Compared to Horsepower in the Cement Industry*, M. A. Rickard.

Ceramic Raw Materials

Papers to be presented under the heading of Ceramic Raw Materials are: *Recent Research Development in High-Aluminous Refractories*, Kenneth Skinner; *Kyanite Resources of the U. S.*, Gilbert Espenshade; and *The Status of Block-Steatite Talc Substitutes*, Donald R. Irving.

Gerald M. Friedman will discuss *Geology of Emery Deposits*, during presentation of material on Special Sands and Abrasives. Other papers in the same field are: *High Purity Silica Abrasives*, Tom Murphy; *A Survey of Special Sands and Abrasives*, T. H. Janes; *A Paper on Industrial Diamonds as Abrasives*, Frank Koebel; and other papers dealing with special abrasives.

Rare Minerals will be covered in: *Monazite Dredging and Concentration in Idaho*, J. H. Carpenter and R. V. Spencer; *Selenium as a Strategic Mineral*, J. D. Sargent; *Development of Monazite Exploration Techniques*, R. F. Griffith; *Chemical and Mineralogical Characteristics of Titaniferous Concentrates from North Carolina, Quilon, Brazil, and Florida Beach Sands*, L. E. Lynd, H. Sigurdson, C. H. North, and W. W. Anderson; and *Monazite Deposits of the Southeastern States*, J. B. Mertie.

Program of the Mining Subdivision was published in MINING ENGINEERING for October. Subsequent issues will contain additional information and finalized programs for the entire Mining Branch.

El Paso Meeting Hailed as One of Year's Best by 700 Members and Wives

by C. M. Cooley

More than 700 members and wives attended the El Paso Meeting of the Mining and Geology Subdivisions, held in conjunction with the International Mining Days, October 29 to 31. Delegates came from all parts of the United States and Mexico.

The meeting was opened with the Welcoming Luncheon on October 29 where more than 400 gathered to hear Felix Wormser, Assistant Secretary of the Department of the Interior, discuss the outlook for the mining industry. Ben D. Roberts, general chairman of the International Mining Days, 1953, presided at the luncheon.

After being introduced to the gathering by Representative Ken Regan, Mr. Wormser discussed the reasons a firm mineral policy is needed and what is being done about it. He expressed the great problems of the industry in a concise statement:

"I don't have to remind you that mining is a hazardous one-crop proposition, and that the lag between discovery and actual production is measured in years, not months.

"With very fickle markets it is no wonder that mining has its ups and downs. It is a credit to the mining industry as a whole that it has continued to prosper despite the many handicaps surrounding its operations."

Thursday afternoon was taken up by technical sessions with Lloyd Nelson and Howard Quinn as co-chairmen. The papers given were related to the geology of various deposits of the West and Mexico. Fred Howell discussed new ideas regarding genesis of the huge Climax molybdenite deposit. Thomas Clendenin and William Hewitt, both old-timers in Mexico, discussed American Smelting & Refining operations in that country. The mines described were operated by the Spaniards some 400 years ago. William Jones presented valuable information on the Central Mining District in New Mexico.

The evening of the first day of the meeting was *ad lib*, just to provide for the tourist instincts of the delegates, and a large number were interested in shopping in Mexico.

Highlight of the following morning was the second technical session led by chairmen John Allen and Edwin McKee. In the first portion of the program water resources of Arizona and New Mexico were spotlighted by L. C. Halpenny and C. S. Conover. After a recess A. F. Shride spoke on the chrysotile deposits of Arizona. Some delegates traveled several thousand miles to hear what Mr. Shride had found. Robert Balk concluded the morning with *Spurrite Deposit, Tres Hermanas Mountains, New Mexico*.

Andrew Fletcher, AIME President, addressed the International Mining Days General Luncheon, held at the Cortez Hotel. In his speech, Mr. Fletcher disputed the idea that the U. S. is a "have not nation."

Felix Wormser, Assistant Secretary of the Interior, spoke at the Welcoming Luncheon. He discussed the necessity for a firm mineral policy for the country, and emphasized the "one-crop" nature of mining.

A luncheon group of 500 of the International Mining Days delegates and AIME members heard Andrew Fletcher, President of AIME, discuss *Maintenance of the Lead and Zinc Industry in the United States*.

Mr. Fletcher stated in his speech that he disagrees with the idea that the U. S. is a "have-not" nation and said, "It seems to me that during the last two administrations, our State Department, and many of our so-called free traders have been in-

The Ranchero Breakfast was one of the most successful of the social functions at the El Paso Meeting. Entertainment was supplied by the diners.

International Mining Days General Luncheon was one of the best functions. From left to right at the head table are: Homer C. Hirsch, Denton Morrow, T. O. Evans, F. O. Davis, T. M. Cramer, Ben Shantz, and Ben D. Roberts, IMD Chairman.

clined to paint depressing pictures of our domestic mining industry in order to justify their own views. They overlook the basic fact that a prosperous mining industry will create needed raw materials."

W. H. Goodrich presided at the luncheon Friday. The afternoon was taken up with a meeting of the New Mexico Mining Assn. W. P. Morris, president of the Association, was chairman and Ken Regan, Congressman, 16th District of Texas was the principal speaker.

The AIME Banquet on Friday evening in the Cortez Hotel Ballroom was the big affair of the convention. B. B. Kunkle, chairman of the El Paso Metals Section, AIME, acted as toastmaster and Cameron Ralston, internationally famous lecturer and humorist, was the featured speaker. His witty talk was well received. Everyone felt that the evening was a contribution to the success of the meeting.

Saturday morning was off to a fast start at 7:30 with the now-famous Ranchero Breakfast of eggs, bacon and beans. Entertainment came from the crowd when individuals were called to the stage by the adjudicator, Chris P. Fox. Amateur singing and a contest for the biggest head in the group were the show stoppers.

Technical sessions followed the breakfast with Joe P. Smith and John Wood as co-chairmen. John Allen presented data on *Bentonitic Shales of the Upper Mesa Verde, San Juan Basin, N. Mex.*, followed by G. A. Kierch with a progress report on *Mineral Resources Survey, Navajo-Hopi Reservations, Arizona.* John W. Anthony discussed *Gypsum Deposits of the Navajo Reservation, Arizona,* followed by Robert H. Weber on *Technologic Problems in Processing Perlite.*

Harrison Schmitt was chairman of the Mining, Geology, and Industrial Minerals luncheon. Guests of honor included Eugene M. Thomas, chairman of the technical committee, and Lloyd Nelson, program chairman.

Cameron Ralston, speaking at the AIME Banquet, lent his famous wit to the affair. Internationally known as a humorist and teller of stories, his stint was well received.

The luncheon for the ladies was held at the Hilton Hotel. Seated from left to right are: Mrs. C. T. Ivey, Mrs. Ken Regan, Mrs. R. J. Benson, Mrs. Mallory Miller. Standing: Mrs. Ben Roberts, Mrs. Andrew Fletcher, and Mrs. R. G. Ponsford, Jr.

The final technical gathering followed the luncheon. Co-chairmen were Eugene Callaghan and Eldred Wilson.

Robert L. Wilson, a geologist of the Indian Service Geology Project, University of Arizona, discussed *Bentonitic Clays of the Chinle Formation, Echo Cliffs Area, Arizona.*

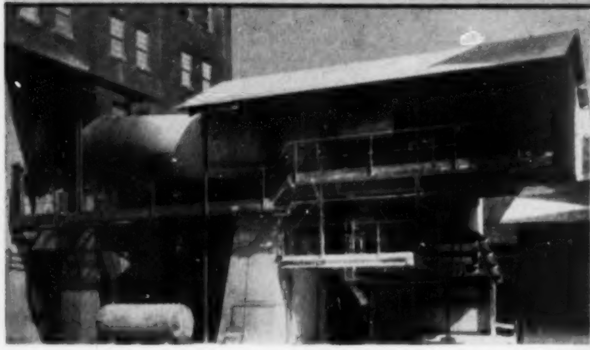
A lecture on *Bleaching Clays of Tertiary Age in the Southwest Quarter of the Navajo Reservation, Arizona,* was presented by Paul W. Howell, of the University of Arizona.

Growth of the flagstone industry of northern Arizona was explained by H. Wesley Peirce, also of the University of Arizona.

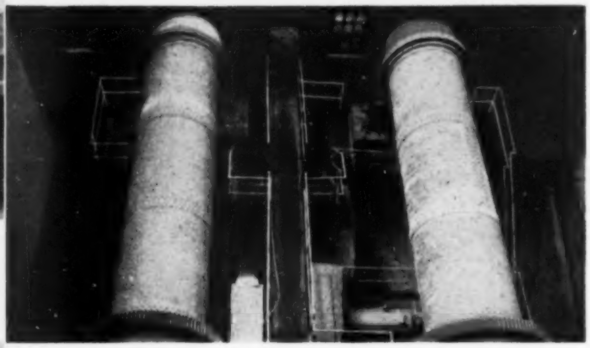
A carryover from Thursday's session, *Coahuila Fluorspar*, was delivered by William Hewitt, American Smelting and Refining Co., Santa Eulala, Mexico.

Final event of the meeting was the Suppliers' Buffet Party at the El Paso Coliseum. Over 800 attended the affair and were entertained by a Mexican orchestra and lady wrestlers.

VULCAN-NEW JERSEY ZINC-WORKING



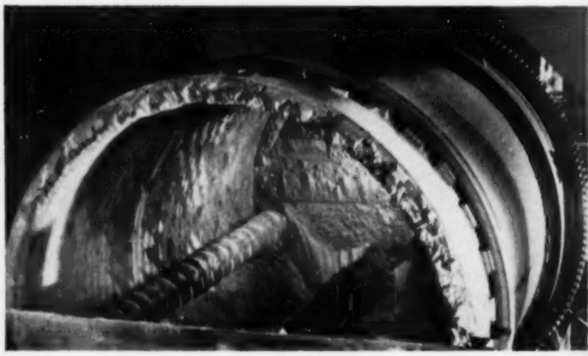
7' x 60' KILN, ORIGINALLY USED FOR BARIUM ORE REDUCTION NOW USED FOR RE-HEATING OXIDE.



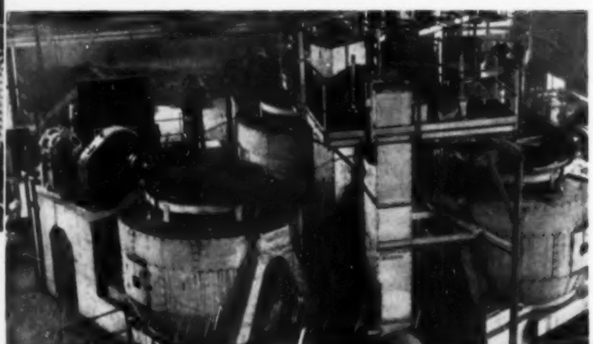
TWO 6' x 50' ROTARY KILNS FOR REDUCTION OF BARIUM ORE.

NEAREST KILN 10' x 140', ORIGINAL INSTALLATION FOR TREATMENT OF LOW GRADE ZINC ORE.

LATEST KILN, 11' x 3" x 161' FOR WAELZ PROSESS.



10' x 14' SPECIAL PELLETIZING DRUM.



THREE OF 14—12' DIAMETER CHASERS USED FOR PREPARATION OF MATERIAL FOR BRIQUETTING.

VULCAN IRON WORKS

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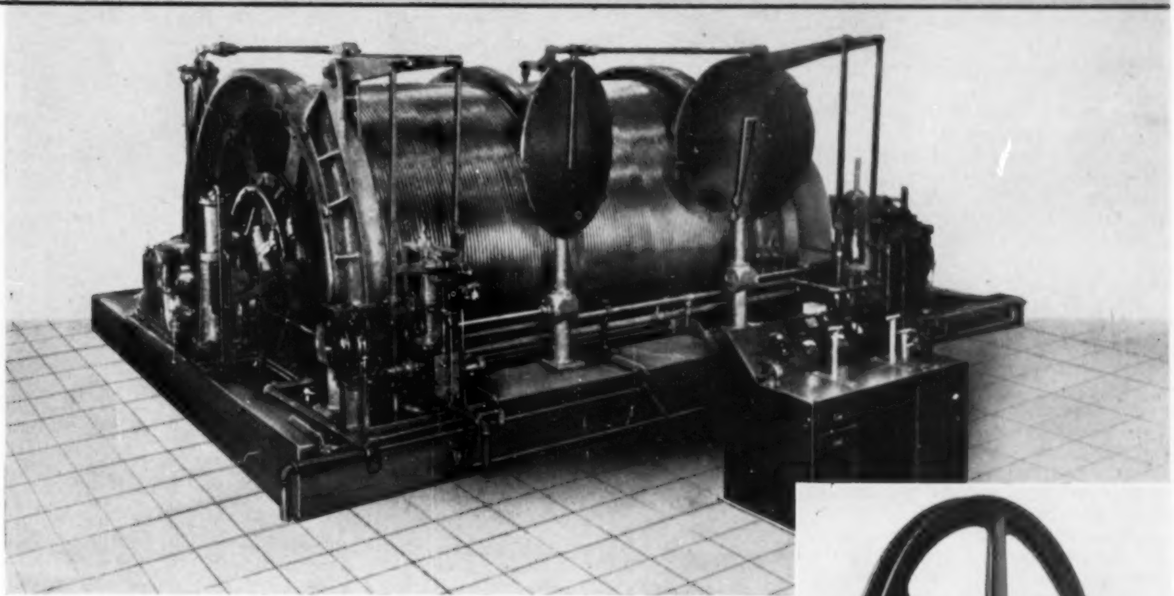
Rotary Kilns, Coolers and Dryers	Improved Vertical Lime Kilns	Double-Roll Briquetting Machines	Steel-Plate Fabrications
Rotary Retorts, Calciners, Etc.	Automatic Quick-Lime Hydrators	Open-Hearth Steel Castings	Shaking-Chute and Chain Conveyors



Fuels Conference Papers Win Approval

The 16th Annual Fuels Conference of the Coal Div. AIME and the Fuels Div. ASME was held at the Conrad Hilton Hotel, Chicago, Oct. 29 to 30, with the Chicago Sections of the two societies cooperating. More than 300 registered and thanks to the propulsive force of the energetic local committees, headed by Carl T. Hayden and John R. Michel, the Conference was a smoothly rolling, highly successful meeting throughout the business of registration, the four technical sessions, two luncheons and the banquet.

Coal took a look at its current competition. Tom Pickett, executive vice president, National Coal Assn., at the Thursday luncheon referred to the inroads of dieselization in transportation, to gas and oil in the field of home heating, and the coming of imported residual oil into coal's markets. He emphasized the necessity for maintaining a strong coal-producing industry. "In today's world," he said, " no nation can remain strong without an adequate coal supply. In another world conflict the outcome might very well depend upon the productive capacity of the coal industries behind the lines of battle—coal for the steel mills, for the electric utilities, the atomic energy plants, the explosives industries, and for conversion into synthetic fuels and a thousand-and-one other uses."

Natural gas—the "hussy"—an appellative that brought approving smiles, was covered Friday morning by K. B. Nagler, vice president of operation, Peoples Gas Light & Coke Co., in his very informative paper on natural gas supply for Chicago and the Middle West. The listeners were told that despite the enormous expansion of the natural gas industry, the proved recoverable natural gas reserves in the United States have been increasing more rapidly than the consumption. Citing the American Gas Assn. estimates of natural gas reserves for 1948, 1951, 1952, and 1953, Mr. Nagler observed that on the assumption that the rate of production will soon be about 8 trillion cu ft per year, a life of 25 years is indicated. "Deeper drilling and offshore gas pools may serve to slow up the rate of increase of natural gas at the field. In the New England area high priced natural gas has to compete with a well-developed high Btu oil gas process. Certain balancing factors are making themselves felt."

"After natural gas—what?" Mr. Nagler asked in conclusion. "Of the presently known sources of primary energy, only coal appears to be so plentiful as to be a future source of gas. A complete gasification process with upgrading of gas to high heating value by synthesis seems indicated. The industry is already studying the problem of replacement when natural gas reserves begin to decrease significantly."

Stopping for a brief moment during the busy Chicago Fuels Conference are, from left to right: J. B. Morrow, Julian Tobey, and M. A. Herder. More than 300 registered for the conference.

Robert E. Wilson, board chairman, Standard Oil Co. (Indiana), principal speaker at the Friday luncheon, brought his listeners up to date on research in fuels for internal combustion engines. Coal, the good, old stand-by (interpreting the sentiment of the Conference, and not quoting) would have its day, sometime. Dr. Wilson predicted that even at the distant time when there is not enough liquid petroleum to meet the demand, the industry will have natural gas, oil shale, and finally, coal, from which it can make liquid fuels.

The papers on the program for the technical sessions were presented in the order of the program on page 933 of the September MINING ENGINEERING, and they will be available as published by either, or both, of the participating societies. The precise title of J. D. A. Morrow's paper is *Coal Developments in the USSR.* It was discussed by L. E. Young, Paul Weir, L. C. Campbell, Gordon MacVean and others. Information proffered was that there are 235 continuous mining machines of all types in the United States and additional machines in Canada. Sixty-five machines will probably be sold, so that the end of the year there will be about 300 in use.

After the very wonderful cocktail party Thursday evening came the banquet. At the latter, presided over by Alex D. Bailey, F. S. Blackall, Jr., president ASME, and M. D. Cooper, Chairman-elect, Coal Division AIME, extended official greetings to the members of the two societies. The former outlined the status of the campaign for a new Engineering Societies Building, stating that the present building is obsolete, the societies having grown tenfold in recent years. H. W. Johnson, vice president, Inland Steel Co., principal speaker, presented a history of the steel industry in the Chicago area, where is produced 22 pct of the nation's steel. He assured the members that they would have a good customer in the steel industry for a long time to come. Incidentally, Mr. Johnson extended a general invitation to his listeners to stop at his farm and crack black walnuts on a section of bessemer rail, mounted on a wood block, the brand on the rail indicating that it was 70 years old. Much of this old rail now coming back to the plant has served for years on main lines before relegation to the side tracks.

At the banquet the Percy Nicholls Award for notable scientific or industrial achievement in the field of solid fuels was conferred by the Fuels Division ASME and the Coal Division AIME on Henry Frederick Hebley, Clayton G. Ball making the presentation. Mr. Hebley's citation reads:

> As a fellow of the ASME and as Chairman of its Fuel Division in 1943, and also as Chairman of the Coal Division of the

AIME in 1946, he has been especially active in promoting the aims of both societies in the field of solid fuels.

His early interest in combustion and in the preparation and sampling of coal has resulted in many important contributions to the technical knowledge of those subjects.

His recent activities in the control and prevention of both air and stream pollution are of outstanding value, both to his fellow engineers and to the public at large.

The next Fuels Conference will be held at the William Penn Hotel, Pittsburgh, Oct. 28 to 29, 1954. At the joint executive committee meeting on Thursday afternoon it was decided by unanimous vote that the 1955 Conference will be held at The Pennsylvania State College, State College, Pa. The college's centennial year is 1955.

Donors to the entertainment at Chicago were: Allen & Garcia Co.; Babcock & Wilcox Co.; Bell & Zoller Coal & Mining Co.; Cardox Corp.; Chicago, Wilmington & Franklin

M. D. Cooper addressed the banquet which topped off Fuels Conference activities.

Coal Co.; Combustion Engineering Inc.; Commercial Testing & Engineering Co.; Commonwealth Edison Co.; N. L. Davis Co.; Edward Valves Inc.; Elliott Co.; Freeman Coal Mining Corp,; General Electric Co.; General Meters & Controls Co.; Illinios Mining Institute; Inland Steel Co.; International Harvester Co.; Joy Mfg. Co.; Link-Belt Co.; MacWeir Coal Corp.; McNally-Pittsburg Mfg. Corp.; Middle States Fuels Inc.; Walter Bledsoe & Co.; Fairview Collieries Corp.; Key Coal Co.; Little John Coal Co.; Little Sister Coal Corp.; Midland Electric Coal Corp.; Old Ben Coal Corp.; Peabody Coal Co.; Peoples Gas Light & Coke Co.; Pioneer Service & Engineering Co.; Pure Oil Co.; Rail to Water Transfer Corp.; Republic Flow Meters Co.; Riley Stoker Corp.; Roberts & Schaefer Co.; Sahara Coal Co.; Sargent & Lundy; Traux-Traer Coal Co.; United Conveyor Corp.; Paul Weir Co.; Worthington Corp.; Morgan Mines Inc.; Republic Coal & Coke Co.; Southern Coal Co.; Sterling-Midland Coal Co.; United Electric Coal Companies.

The ladies accompanying their husbands to the Conference had their choice on Thursday of tours of the Art Institute of Chicago, Chicago Museum of Natural History, and Marshall Field & Co., or of seeing *The Robe* at State Lake Theater. On Friday there was a luncheon at the Kungsholm Restaurant.—E. J. K., Jr.

Drilling Sessions Attract More Than 100

by John V. Beall

More than 100 exploration engineers and geologists, and representatives of drilling contractors, and drilling equipment and bit manufacturers attended the recent Fifth Annual Drilling Symposium sponsored by the University of Minnesota Center for Continuation Study, with the help of the Exploration Drilling Committee of the AIME.

About 16 papers were presented in two and a half days of technical sessions devoted to drilling practices for uranium on the Colorado Plateau, orientation of diamonds in drill bits, use of drilling muds, and new equipment.

M. E. Crew, reading a paper he prepared with D. B. Hurley, on AEC policies and procedures in the exploration drilling program, reported that future drilling contracts would call for a greater proportion of deep holes and noncore drilling. They would also stipulate larger cores with nothing smaller than BX, and a greater user of dry, noncore drilling.

The contractors' viewpoint on Colorado Plateau drilling was presented by A. E. Ross of Sprague & Henwood Inc. In his opinion the exploration costs for uranium ore approached that of the in-place value of the ore. Mr. Ross also noted that Sprague & Henwood prefers the I-R 600 cfm compressor, single tube-core barrels except when core recovery falls off, fluid coupling torque converters, diesel engines over gas engines for power, oriented diamonds in bits, tungsten carbide insert grips on chuck and foot clamps, and air drilling over water and Tricone bits.

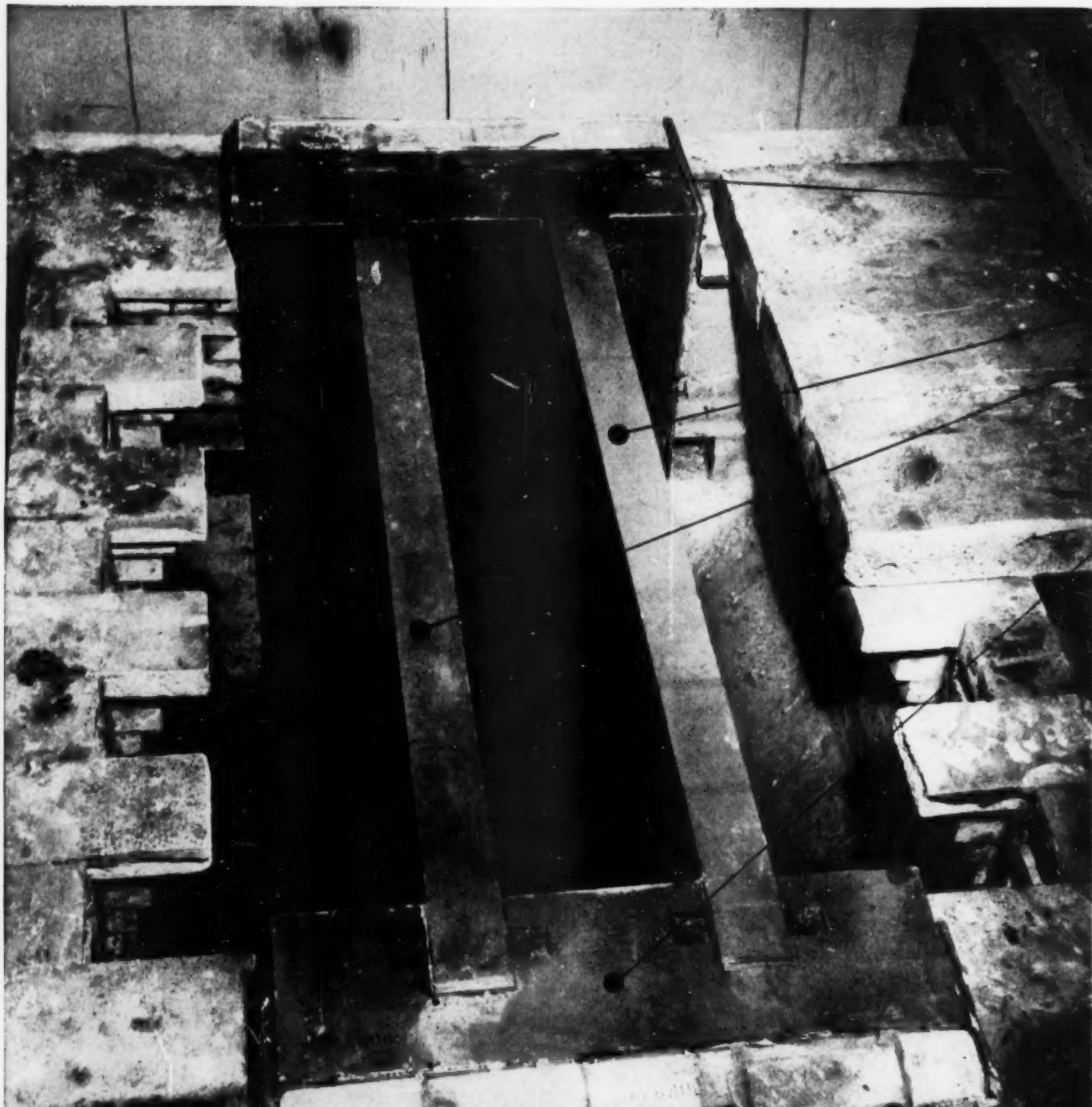
An animated discussion followed presentation of papers by A. G. Long and E. P. Pfleider on orienting diamonds in drill bits. This is a procedure for setting diamonds in the bit face to take advantage of hard vectors on the leading edges, orientation of cleavage planes to minimize fracture, and proper backing of the diamond. Substantial contributions to the discussion were made by Wing Agnew, W. H. Hampton, C. B. Slawson, and E. M. Jenkins.

Drilling mud as an aid to diamond drilling for mineral deposits was discussed in excellent papers by W. D. Lacabanne. Kai Wohlleben, R. F. Durfee with Paul A. Park, and M. Gleason with E. J. Tucker. The papers covered technology of drilling practice and muds in Canada, the Far West, and the Lake Superior region. Boyles Bros. found that the use of mud was the only way to core drill an asphaltic formation which flowed with molasses-like consistency. Mud is also used for drilling effectively through fractured rocks.

Another paper, presented by H. B. Woods, dealt with the use of air in rotary rock bit drilling. Mr. Woods stated that air or natural gas gives faster drilling than water circulation and recommended velocities of 3000 fpm return air in the hole. He also recommended tool weights of 4000 to 6000 lb per in. of bit diam for best drilling with rock bits.

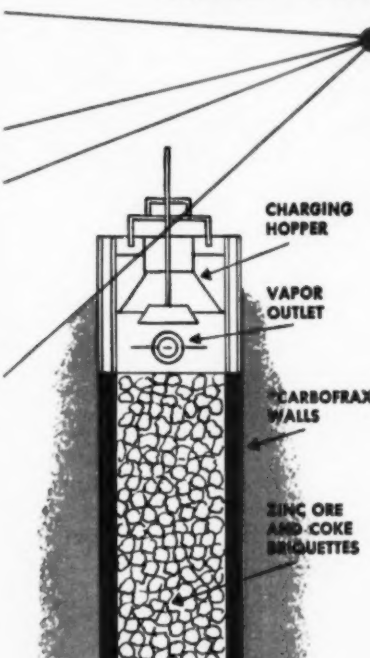
R. G. Sullivan reported that air drilling had worked well for his firm on the Plateau but that is was not a cure-all. Some holes could not be finished because water was encountered.

A session on new equipment presented information on manufacturers' claims that were borne out by contractor experience. Fluid couplings described by A. O. Lee and J. N. Yetter have many uses in practice. Robert Carver described his company's experience with diesel enines, stating that they were more economical and ran more smoothly. R. Waddington described an underreamer which worked well in softer formations. M. W. Bremner presented a paper on the use of tungsten-carbide bits in Canadian gold mines. R. H. Nesbitt made what was termed a unique contribution to the meeting with his excellent discussion and exhibition of the NX bore hole camera which takes a 360° picture.



The top of a partly completed vertical retort shows walls of CARBOFRAX silicon carbide brick.

How NEW JERSEY ZINC used the unique properties of SILICON CARBIDE



DIAGRAMMATIC SKETCH OF VERTICAL RETORT.

2,000°F. *inside* a retort is required to reduce zinc from its ores at a practical rate. And some five million BTU's must be pumped through the retort walls for every ton of zinc produced.

When New Jersey Zinc developed its continuous Vertical Retort Process they required a refractory with high heat conductivity, low permeability (to contain the gas-vapor mixture), and high strength and wear resistance at high temperature as well as chemical resistance to the firing gases outside, and the products of reduction inside the retort.

CARBOFRAX®, the silicon carbide refractory made by The Carborundum Company was able to meet these drastic requirements.

CARBOFRAX shapes have also been used by New Jersey Zinc in their Vertical Redistillation Process for the production of Special High Grade zinc.

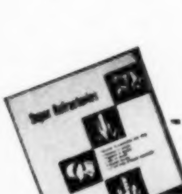
The New Jersey Zinc Company's development of the Vertical Retort Process was the first *continuous* zinc reduction process on a commercial scale.

CARBOFRAX silicon carbide refractory has roughly 11 times the heat conductivity of fireclay. It has the hot strength to support itself and the charge. It has the impermeability necessary to contain the gases. It is chemically inert—both to zinc oxide and vaporized zinc. And it is one of the most wear-resisting materials known.

This application illustrates the important thing about Super Refractories by CARBORUNDUM. They are not just "better" than standard fireclay refractories. They are a class apart—with a variety of properties not found in other refractory materials. Once this is realized, there is no predicting what new processes can be developed.

WHAT ABOUT YOUR OWN PROCESSES? The coupon will bring you the story of our special-purpose Super Refractory materials—or one of our engineers will be happy to talk over specific problems.

In any indirect heating process like this, absorption and emission factors come into play, as well as thermal conductivity. In both of these respects, CARBOFRAX refractories are superior to metal. In conductivity, they approach the high-temperature alloys.



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Registered Trade Mark

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Please send free copy of Super Refractories booklet to:

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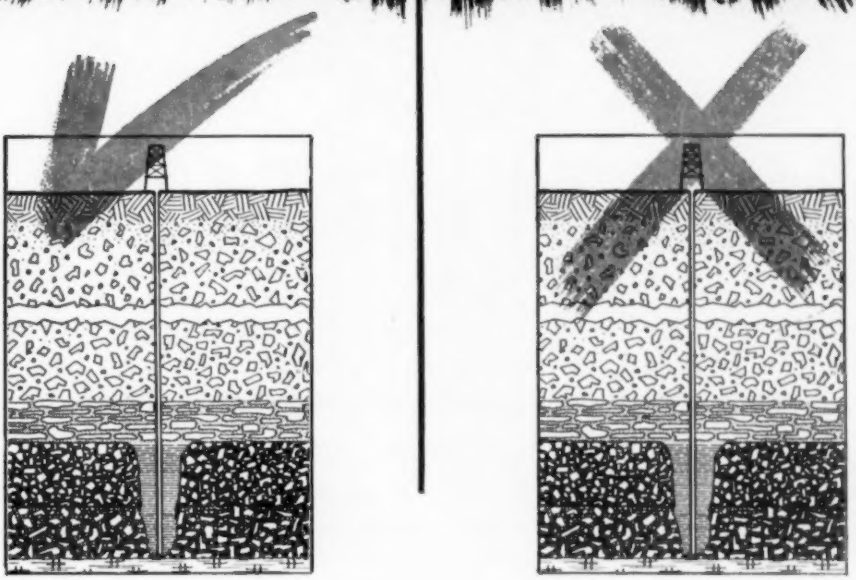

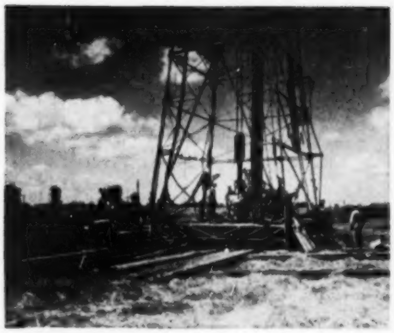

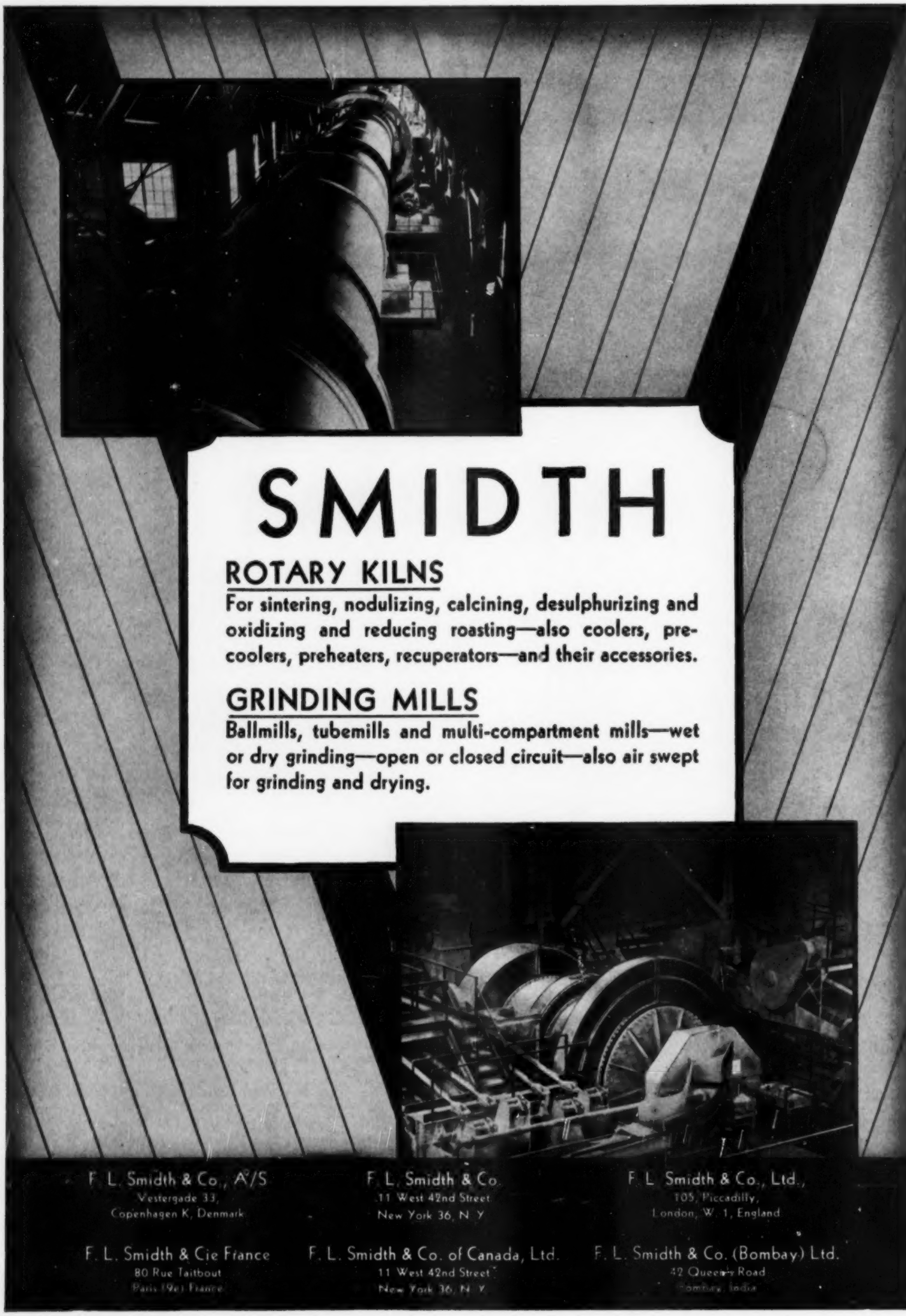
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Around the Sections

• Reinhardt Schuhmann, Jr., MIT professor, spoke at a recent meeting of the **Boston Section,** presenting personal ideas on how metallurgical knowledge could be best condensed for instructional purposes during the limited undergraduate period. At the same meeting Russell Buehl discussed Bureau of Mines' work in treating low grade manganese ores. Harrison Dixon was named Chairman of a committee to make recommendations for improvement of the Section's financial condition. Next meeting of the Boston Section is scheduled for December 7 at the MIT Faculty Club.

• Opening meeting of the fall series of the **San Francisco Section** was highlighted by an address by D. N. Vedensky. He discussed the M. A. Hanna Co. program at Riddle, Ore., aimed at the development the fourth largest nickel producer in the world. At another meeting of the Section, A. G. Zima of International Nickel spoke on *Ductile Cast Iron.*

• An unusually large proportion of students filled the audience at a meeting of the **St. Louis Section** to hear Eugene W. Dunlap, St. Louis University instructor, speak on *Opportunities in Metallurgy.* The meeting also affirmed the action of the Executive Committee in recommending establishment of the Arkansas Bauxite Subsection.

• Andrew Fletcher, AIME President, spoke at a dinner meeting of the **Morenci Subsection** held at the Longfellow Inn. He discussed problems of the lead and zinc industry and his solution for maintaining a healthy U. S. industry.

• A technicolor movie, *Cerro Bolivar,* describing U. S. Steel Corp.'s Orinoco mining project was seen by members of the **Chicago Section** at a Ladies' Night dinner meeting.

• Francis Sterner, Lehigh Navigation Coal Co. mining engineer, arranged an outstanding technical program for the Annual Fall Meeting of the **Pennsylvania Anthracite Section.** Papers heard were: *Brief History of Timbering,* Harry Otto, Hudson Coal Co.; *Roof Bolting at Hudson Coal Co.,* Weseley Stonebreaker, Olyphant Colliery; *Collapsible Props,* Norman Becker, Alden Coal Co.; and *Full Ring Yielding Member Steel Timber,* Charles Kuebler, Lehigh Navigation Coal Co.

• Felix Wormser, Assistant Secretary of the Interior, spoke on the aims and operations of his department before the **Carlsbad Potash Section.** Andrew Fletcher, AIME President, gave a financial report on the Institute and outlined benefits of membership.

• Edward H. Robie, AIME Secretary, spoke on his travels to various local sections before the **Black Hills Section** at a meeting in Hill City, S. Dak. He also reported on the recent American Mining Congress meeting in Seattle.

• Some 160 persons attended the All Sectional meeting of the **Southeast Section** at Knoxville, Tenn. E. H. Rose, Section Chairman, presided over the session. C. E. Larson, director of the Oak Ridge National Laboratory, spoke on *Implications of the Atomic Energy Program for the Mining and Metallurgical Industry* at the banquet held the first evening of the meeting. Registrants toured the Oak Ridge Laboratory during the day. Technical sessions dealt with a wide range of topics.

• Baldwin-Lima-Hamilton Corp., Construction Equipment Div., Lima, Ohio, has a 16 mm color sound film, *The Loggers' Giant,* which is available to AIME Sections. A narrative-type travelogue, it shows Lima machines in action and tells the story of the logging industry, against the Paul Bunyan background of the Pacific Northwest.

Nominating Committee for AIME Officers, 1955

The following have been named by the Council of Section Delegates, the Branch Councils, and the President of the Institute to constitute the Nominating Committee for AIME Officers in 1955. The Committee will meet during the Annual Meeting of the Institute in New York, Feb. 15 to 18, 1954 and select the official slate. If the principal finds it impossible to attend, the alternate will act in his place; otherwise the alternate will not be present at the meeting of the Committee. The names of alternates are given in parentheses.

Mining Branch Council: A. B. Cummins, Johns Manville Co. Research Center, Manville, N. J. (R. M. Foose, Dept. of Geology, Franklin & Marshall College, Lancaster, Pa.); R. E. Byler, The Merrill Co., 582 Market St., San Francisco 4, Calif. (Will Mitchell Jr., Allis-Chalmers Mfg. Co., P. O. Box 512, Milwaukee 1.

Metals Branch Council: T. D. Jones, American Smelting & Refining Co., Barber, N. J. (Walter A. Dean, Aluminum Co. of America, 2210 Harvard Ave., Cleveland, Ohio.)

Petroleum Branch Council: Paul Turnbull, Wilson Tower, Corpus Christi, Texas. (R. W. French, Jr., Sohio Petroleum Co., 1300 Skirvin Tower, Oklahoma City, Okla.)

Council of Section Delegates, Executive Committee: Fred J. Meek, American Zinc Co. of Illinois, Box 495, E. St. Louis, Ill. (Roy Sullins, Humble Oil & Refining Co., Box 626, New Orleans 7, La.)

New York Section: John H. Ffolliott, Miami Copper Co., 61 Broadway, New York 6, N. Y. (G. Howard Le Fevre, U. S. Smelting Refining & Mining Co., 57 William St., New York 5, N. Y.)

Detroit Section: Richard D. Chapman, Chrysler Corp., Box 1118, Detroit 31, Mich. (Frederick P. Bens, Climax Molybdenum Co., 14410 Woodrow Wilson Ave., Detroit 3.

Philadelphia Section: F. J. Dunkerley, 247 Engineering Bldg., University of Pennsylvania, Philadelphia, Pa. (F. B. Litton, Foote Mineral Co., P. O. Box 576, Berwyn, Pa.)

Florida Section: J. L. Weaver, American Cyanamid Co., Brewster, Fla. (Felix J. Losson Jr., 1400 Lake Bonny Drive, Lakeland, Fla.)

Central Appalachian Section: Veleair C. Smith, Kanawha Valley Bldg., Charleston, W. Va. (George E. Keller, Commercial Testing & Engineering Co., Charleston, W. Va.)

Nevada Section: John C. Kinnear Jr., Kennecott Copper Corp., McGill, Nev. (Vernon E. Scheid, Mackay School of Mines, Reno, Nev.)

Wyoming Section: M. O. Hegglund, 1974 S. Cedar St., Casper, Wyo. (B. W. Allen, Ohio Oil Co., P. O. Box 120, Casper Wyo.)

Southern California Section: John S. Bell, Humble Oil & Refining Co., 612 S. Flower St., Los Angeles 17.

Permian Basin Section: Jack M. Moore, Dowell Inc., P. O. Box 1858, Midland, Texas. (James C. Blackwood, Amerada Petroleum Corp., P. O. Box 312, Midland, Texas.)

North Texas Section: Rollie P. Dobyns, U. S. Bureau of Mines, Box 612, Wichita Falls, Texas. (R. B. Gilmore, DeGolyer & MacNaughton, 5625 Daniels Ave., Dallas, Texas.)

President Fletcher's appointments: Grover Holt, Cleveland-Cliffs Iron Co., Hibbing, Minn. (Walter Penick, Western Precipitation Corp., San Francisco.) Edward G. Fox, Philadelphia & Reading Coal & Iron Co., Philadelphia, Pa. (W. W. Everett, Glen Alden Coal Co., Wilkes-Barre, Pa.); John Golden, U. S. Steel Corp., Pittsburgh, Pa. (T. S. Washburn, Inland Steel Co., Chicago, Ill.)

Members of the Institute are invited to write to the Chairman, or any or all members of the Committee, suggesting the name of a candidate for President-Elect for 1955, a Vice-President, or a Director. One President-Elect is to be named, two Vice-Presidents, and six other Directors.

Legion of Honor — Class of 1904

Each year, at the Annual Banquet in February, those members of the AIME who have continuously maintained their membership for 50 years are given special recognition. They are seated at the head table as guests of the Institute and are added to the membership of the Legion of Honor. The list appears on page LXVI of the current Directory, and the names of those who will achieve this status in 1954 are as follows:

Blow, John J.
Barbados, B. W. I.
Boutwell, John M.
Salt Lake City, Utah
Boynton, Arthur J.
Chicago, Ill.
Brooks, John M. Jr.
El Paso, Texas
Bryant, George W.
Los Angeles, Calif.
Cates, Louis S.
New York, N. Y.
Channing, R. H.
New York, N. Y.
Cobb, H. McL.
Guanacevi, Dgo., Mexico
Dakin, Frederick H.
Burlingame, Calif.
Fohs, F. Julius
Houston, Texas
Goodale, Stephen L.
Pittsburgh, Pa.
Guernsey, F. W.
Vancouver, B. C., Canada
Hunter, H.
Tokyo, Japan
Jones, Charles H.
Forfar, Scotland
Lindsay L.
Chichester, England
Mills, Edwin W.
Salome, Ariz.
Paymal, George W.
Altadena, Calif.
Pelton, Roger T.
La Jolla, Calif.
Posada, Juan de la C.
Antioquia, Colombia
Prout, John W., Jr.
Beverly Hills, Calif.
Schroter, George A.
Brooklyn, N. Y.
Swanquist, G. A.
El Salvador, Central America
Wright, Louis A.
Palo Alto, Calif.

1954 Publications' Policies Established

Pursuant to Article X of the bylaws of the AIME, the following information is hereby given as to the "conditions, prices, and terms under which the various classes of Members, and Student Associates, severally, shall be privileged to obtain publications of the Institute during the ensuing year."

Publications authorized for issue in 1954 include the following: MINING ENGINEERING, published monthly, containing material, including technical papers, of interest to those engaged in exploration, mining geology and geophysics, and metal, nonmetallic, and coal mining and beneficiation, and fuel technology. The JOURNAL OF METALS, published monthly, containing material, including technical papers, of interest to those engaged in nonferrous smelting and refining, iron and steel, and physical metallurgy. The JOURNAL OF PETROLEUM TECHNOLOGY, published monthly in Dallas, containing material, including technical papers, of interest to those engaged in petroleum and natural gas drilling and production.

Annual subscriptions to any one of the above journals will be provided all Members in good standing without further charge. (A Member ceases to be in good standing if current dues are not paid by April 1). If more than one of the monthly journals is requested, \$4 extra will be charged for an annual subscription, or 75¢ for single copies of regular issues and \$1.50 for special issues. The nonmember subscription price for each journal is \$8 in the Americas; foreign, \$10, and for single issues \$1 for regular issues and \$2 for special issues. Student Associates will be entitled to the same privileges for all publications as Members. AIME Members subscribing to more than one of each of the three monthly journals will be billed at

(Continued on page 1304)

(Continued from page 1303)

the nonmember rate of $8 per year, domestic; $10 foreign, for the extra subscription(s).

Three volumes of *"Transactions"* are authorized for 1954 publication, as follows: No. 196, Mining Branch; No. 197, Metals Branch; and No. 198, Petroleum Branch. These volumes will be available to Members at $3.50 each for a first copy if paid for in advance with dues; otherwise at the nonmember rate of $7 less 30 pct. Nonmembers $7 in the United States; foreign $7.50.

Special volumes now planned for publication in 1954 include the following: 1—*Open Hearth Proceedings*, Vol. 37, price to AIME Members $7; nonmembers, $10. 2—*Blast Furnace, Coke Oven, and Raw Materials Proceedings*, Vol. 13, AIME Members $7; nonmembers $10. 3—*Electric Furnace Steel Proceedings*, Vol. 11, AIME Members $7; nonmembers $10. 4—*Dislocations in Metals*, $5. 5—*Statistics of Oil and Gas Development and Production*, Vol. 8, covering data for the year 1952, Members $5, nonmembers $10. 6—*Index to AIME Petroleum Publications*, 1900 to date, $7 less 30 pct discount to AIME Members. 7—AIME *Directory and Yearbook*, free to Members. 8—Reprint of *Ore Deposits of the Western States* (Lindgren volume), price to be announced.

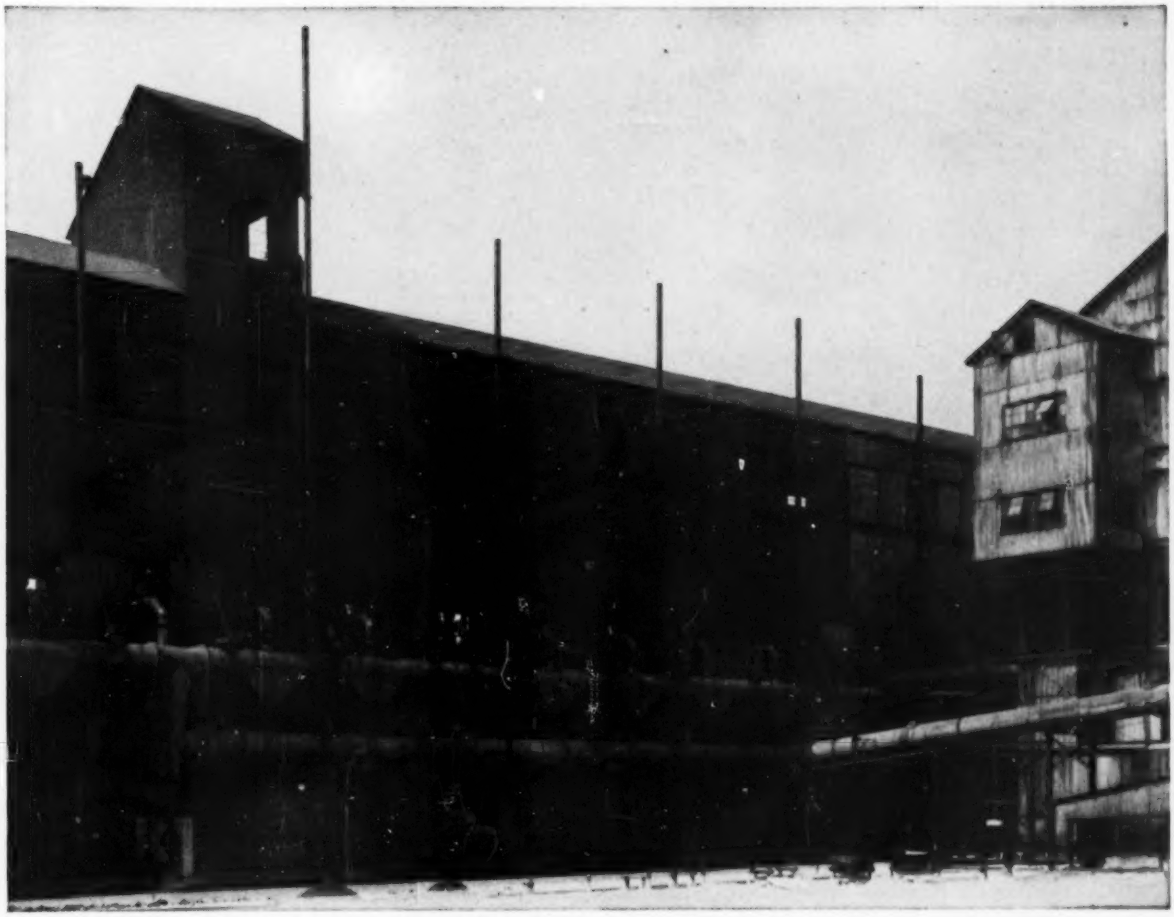
If dues are paid subsequent to January 31, back issues of Institute publications will be supplied only if adequate stocks are on hand. A Member may not receive a volume of *"Transactions"*, or a special volume, in lieu of a monthly journal, free of charge on membership. Members in arrears for dues are not entitled to special Members' prices for publications.

Rocky Mountain Members may have their choice of an annual subscription to one of the monthly journals on request.

Mail Dues Bills To AIME Membership

Pursuant to Article II, Section 2, of the bylaws of the AIME, notice is hereby given that dues for the year 1952 are payable Jan. 1, 1954, as follows: Members and Associate Members, $20; Junior Members for the first six years of Junior Membership, $12 and thereafter, $17; Student Associates (including an annual subscription to a monthly journal), $4.50.

Dues bills were mailed early in November. Prompt payment will assure uninterrupted receipt of the publications desired in 1954. If, for any reason, a bill is not received within a reasonable time, headquarters should be notified.



Personals

Fred Elon Johnson has resigned as superintendent of Gossan mines, General Chemical Div., Allied Chemical & Dye Corp., Galax, Va., and has accepted the position of general manager of Christmas mine, Riviera Mines Co., Christmas via Winkelman, Ariz.

Austin E. Jones, geophysicist, USGS, formerly in Washington, D. C., is now in Unalaska, Alaska. Mr. Jones expects to be there for the winter.

Otto M. Ellerman is with American Colloid Co., Belle Fourche, S. Dak., as a construction and mining engineer. He was with Holy Terror Mining Co., Keystone, S. Dak.

J. A. Christensen, Pacific Western Oil Corp., is in Kuwait, Persian Gulf, as petroleum geologist and representative in Pacific's joint operation in the Kuwait-Saudi Arabia Neutral Zone.

Roy H. Glover is now vice president and general counsel of Anaconda Copper Mining Co., New York. Mr. Glover also maintains a business address in the Hennessy Bldg., Butte, Mont.

Melbourne W. Miller is district sales manager for Euclid Road Machinery Co., Cleveland.

Oliver Bowles and **Lincoln A. Stewart** of the U. S. Bureau of Mines recently returned from a mine inspection mission in Venezuela.

RICHARD M. FOOSE

Richard M. Foose recently inaugurated the season for the Pittsburgh Geological Society with an illustrated geological lecture on Europe and North Africa. Mr. Foose, head of the geology dept., Franklin and Marshall College, Lancaster, Pa., was a delegate to the International Geological Congress in Algiers. Another recent speaker at the PGS was **William M. Fiedler,** chief geologist for Jones & Laughlin Steel Corp., Pittsburgh.

George H. Israel has retired from Lehigh Navigation Coal Co., Philadelphia, where he was service manager. Except for periods of military service in the Mexican border campaign and World War I, Mr. Israel has been employed continuously by Lehigh since 1908, when he started as a water boy at the mines in Lansford, Pa.

Floryan J. Tokar, formerly with the Quigley Co., is a representative for Chas. Taylor Sons. Co., a subsidiary of National Lead Co., manufacturers of special refractories. His headquarters will be in Chicago and his territory will include Wisconsin and sections of Illinois, Indiana, and Iowa.

Jay A. Poll is superintendent of the Humboldt mine operated by Cleveland-Cliffs Iron Co., Ishpeming, Mich.

Lew Adamec has left Bolivia and is in Trujillo, Peru, with Northern Peru Mining & Smelting Co. He is superintendent of the Quiruvilca mine.

Douglas Castleberry is testing engineer, Weston & Brooker Co., Thomson, Ga.

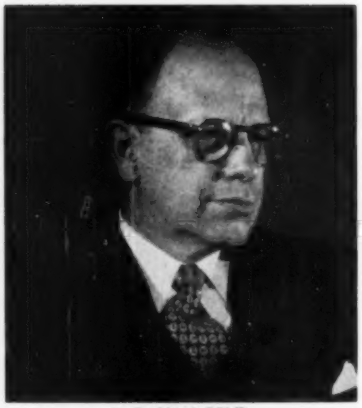
Norman T. Ravnsborg is a design engineer with Western Knapp Engineering Co., New York City.

Otto C. Radley is with Nevada Pacific Mines, Mountain City, Nev. He was with Madrona Mining Co., Pasadena, Calif.

Cornelius F. Kelley, chairman of the board of directors of Anaconda Copper Mining Co., has been honored by the Great Northern Railway which has renamed a station *Conkelley* in his honor. Former station Brent, located two miles east of Columbia Falls, is where Anaconda Aluminum Co., an Anaconda subsidiary, is erecting a $50 million aluminum plant.

L. H. Lange, vice president and manager of the Metallurgical Div., the Galigher Co., Salt Lake City, has returned after a year abroad. He spent five months as consulting metallurgist for Tsumeb Corp. in South West Africa on germanium recovery and two months in Johannesburg working on pyrite recovery. Mr. Lange also made a two month's trip to Australia and returned to South Africa, visiting Northern and Southern Rhodesia, the tin fields in Nigeria, and the Mines de Zellidja, in Morocco before returning to New York via London.

E. M. Platts, executive vice president of Joy Mfg. Co., has been obliged to resign his position because of failing eyesight. Mr. Platts will continue to serve the company, having been employed by Joy as a consultant to its executives and board of directors.



J. R. VAN PELT

Douglas McKay, Secretary of the Interior, has established a survey committee headed by **J. R. Van Pelt,** president of the Montana School of Mines, to investigate and analyze the organization and operation of the USGS and to render a report by Dec. 15, 1953. Other members of the committee are **Samuel G. Lasky,** of the Interior Dept's technical review staff, **John C. Frye,** of the University of Kansas, **William B. Heroy,** Beers & Heroy, Dallas, **Donald M. Davidson,** vice president of E. J. Longyear Co., Minneapolis, and **Horace M. Albright,** president, U. S. Potash Co. Inc., New York.

THOMAS W. MITCHAM

Thomas W. Mitcham has been appointed assistant chief of the geologic branch of the Grand Junction exploration office, AEC. Mr. Mitcham was formerly an exploration geologist for American Smelting & Refining Co., covering southern Arizona.

Arthur J. Maese has been transferred as mine superintendent by American Smelting & Refining Co. from Mina Tiro General, Charcas, San Luis Potosi, to Nuestra Señora Unit, Cosalá, Sinaloa, Mexico.

T. A. Woods-Smith has left Santiago, Chile, where he was with Cia. Minera y Comercial, and is with Bear Creek Mining Co., Arlington, Va.

Ronald Naftal is living in Ouray, Colo. He is employed as a mining engineer by the Idarado Mining Co.

H. J. Emdin is with the engineering office, Tela R. R. Co., La Lima, Honduras. He was with Minas El Mochito.

Whitman E. Brown has resigned as metallurgical engineer with Humphreys Investment Co., Denver, and has been appointed metallurgical engineer and mill superintendent for Acoje Mining Co. Inc., Zambales, Philippine Islands.

Edward R. Weidlein, president of the Mellon Institute of Industrial Research, Pittsburgh, has been elected to the board of directors of the American Institute of Management, a nonprofit foundation devoted to the study and improvement of corporate organization and methods.

RICHARD QUIRK

Richard Quirk is assistant manager, mining dept., National Lead Co., 111 Broadway, New York.

Robert S. Shoemaker has joined the minerals research group of the Metals Research Laboratories, Union Carbide & Carbon Corp., Niagara Falls, N. Y. Mr. Shoemaker received an M.S. degree in metallurgical engineering at the University of Wisconsin in June.

Ralph K. Gottshall, president of Atlas Powder Co., has been elected a life trustee of Lafayette College. Mr. Gottshall received his B.S. in chemistry, magna cum laude, from Lafayette in 1927.

Elmer O. Rodes, Jr., formerly a partner with Robert L. Brown & Associates, is now a partner with Sowers, Knowles & Rodes, also in Roanoke, Va.

Robert M. Hernon, who was with the U. S. Bureau of Mines, is now associated with **G. M. Fowler,** consulting geologist, Knoxville, Tenn.

A. B. Martin is research consultant with the Washington Water Power Co., Spokane. He was chief engineer, The Montana Power Co., Butte.

Earl E. W. Kearly, a former student at the New Mexico Institute of Technology, is now with Northern Peru Mining & Smelting Co., Trujillo, Peru.

James L. Vallely, U. S. Bureau of Mines, has been transferred from Tuscaloosa, Ala., to Knoxville, Tenn.

Leon Estes, who was employed by Magnolia Petroleum Co., as a junior geophysical engineer, is with the 10th Infantry Div., Fort Riley, Kans.

D. Solanke Fraser is with Sierra Leone Development Co. Ltd., Marampa Mines, Freetown, Sierra Leone. Mr. Fraser graduated in June from the South Dakota School of Mines and Technology.

Maurice Gratacap has left Venezuela and is general manager, Intasbest, Johannesburg, South Africa.

L. R. Brown, Jr., is with Cerro de Pasco Corp., Morococha, Peru.

Justin B. Gowen has resigned as chief of the copper branch of DMPA, Washington, D. C., and is with Tennessee Manganese Co., Johnson City, Tenn.

Arthur B. Drescher is mining geologist with Union Pacific R. R. Co., Laramie, Wyo. He was with Kennecott Copper Corp., Riverside, Calif.

Paul G. Leroy is with Bear Creek Mining Co., Eastern District, Arlington, Va.

Emmett G. Easterly has been named manager of Atlas Powder Co.'s explosives sales district in Seattle to succeed **George W. Thompson** who has been recalled to the home office in Wilmington, Del., to become assistant to **W. E. Collins. James M. Ellis** will succeed Mr. Easterly as special representative.

Samuel H. Dolbear and **A. F. Banfield** of Behre Dolbear & Co. have been examining asbestos deposits near St. Odilon, P. Q.

Paolo D. Tradardi is director of Cave Meriolionali S.p.A., Cementir, Coroglio, Naples.

Theodore B. Counselman, Dorr Co., Stamford, Conn., and AIME Vice President recently represented the Institute at the Fourth National Standardization Conference in New York.

D. T. Schueler, Jr., released from active duty by the Navy in July, has taken a position with Helmke, Thomas & Janssen, San Francisco, as superintendent of a plant treating chromite ore, Castella, Calif.

David J. Enochs is now with Piqua Stone Products, Piqua, Ohio.

R. C. Bacon, mining engineer, formerly in New York with Panaminas Inc., is now in Lima, Peru, with Consolidated Guayana Mines Ltd.

R. L. LOOFBOUROW

R. L. Loofbourow is now engaged as consulting engineer, specializing in underground storage and mine development. His address is 4032 Queen Ave. S., Minneapolis.

George A. Brady is with the Glen Alden Coal Co., Hollenback Laboratory, Wilkes-Barre, Pa.

H. E. Hawkes, Jr. is with the geology dept., Massachusetts Institute of Technology, Cambridge, Mass.

Harlan A. Walker is vice president and general manager, Marcona Mining Co., Lima, Peru.

ALEXANDER R. TROIANO

Alexander R. Troiano has been named head of the metallurgy dept., Case Institute of Technology, Cleveland, Ohio. Before coming to Case in 1949, Mr. Troiano was professor and acting head of the metallurgy dept. at the University of Notre Dame.

Garff K. McMullin is development engineer at the Pilotac plant, Oliver Iron Mining Div., Mt. Iron, Minn. He is living in Virginia, Minn.

C. Bloot finished his studies at Delft University in Holland this year and received his Master's degree on a study of the Panasqueira tin-tungsten orebody in Portugal which is soon to be published in Lisbon. Mr. Bloot is now in Monrovia where he is employed by the Liberian Government as an economic geologist.

Obituaries

Appreciation of

Galen Howell Clevenger

by F. S. Mulock

Galen Howell Clevenger (Member 1903) passed away at the Cape Cod Hospital at Hyannis, Mass., on Aug. 2, 1953 after an extended illness.

Though Mr. Clevenger was born in Pike, N. Y., Sept. 1, 1879, much of his early life was spent in South Dakota. He received his B.S. and E.M. degrees from South Dakota State School of Mines in 1901 and 1908, respectively, A.M. from Columbia University in 1903, and Met. E. from Stanford University in 1906.

He was one of the pioneers in the development of the cyanidation process. From 1898 to 1901, while a student at South Dakota, he constructed and successfully operated a plant to treat, by cyanidation, a dump of chlorination tailing adjoining the campus. From 1906 to 1909, he was consulting metallurgist for Charles Butters & Co. Ltd. for its operations in Virginia City, Nev., and San Salvador. From 1909 until 1918 he was successively assistant, associate and research professor of metallurgy at Stanford University. During that period he did extensive research work in connection with all phases of cyanidation as well as along other metallurgical lines in which his associates and students participated, including important work for the Merrill Co., Portland Gold Mining Co., and Nipissing Mining Co. The writer, while instructor in electrical engineering at Stanford, became associated with Mr. Clevenger in 1916 on a research problem for Electrolytic Zinc Co. of Australasia, from which it was first determined that cobalt was an interfering element in the electrodeposition of zinc. The successful outcome of cooperative work conducted in 1917 and 1918 by U. S. Bureau of Mines, Research Corp. of America, and the Dutch East Indies Government on cyanidation of refractory manganese-silver ores, under the direction of Mr. Clevenger and Mr. M. H. Caron, led to a similar study of certain ores of Cia. de Real del Monte y Pachuca and subsequently to Mr. Clevenger's association in 1920 with the parent company, U. S. Smelting Refining & Mining Co., as consulting metallurgist, a position he held until his retirement from active service in 1947. During that period he directed the research work of the company, investigating innumerable problems having to do with all phases of the company's mining, milling, smelting, and refining operations. Without going into detail, suffice it to say that his researches covered a tremendously varied field, his accomplishments were many, and the benefits to the company were great.

An avid reader, Mr. Clevenger always impressed upon his students and those who worked with him, the importance of finding out what others had done. His comment, during discussion of any new problem, of "Let's review the literature," was always expected and always forthcoming. His breadth of knowledge of all phases of metallurgy was phenomenal.

He joined AIME in 1903, was a director from 1920 to 1926, and—until illness overtook him—always was very active in Institute affairs. He was a member of the Mining and Metallurgical Society of America, American Chemical Society, American Electrochemical Society, AAAS, and Sigma Xi, also of the Engineers' Club and Chemists Club of New York, and the Cosmos Club of Washington.

He is survived by his wife, nee Alice Clemens of Centerville, Mass., a daughter Mrs. Thomas F. Burke of West Yarmouth, Mass., a son Galen W. Clevenger of Newtonville, Mass., a brother Henry R. Clevenger of Ashmont, Ark., and four grandchildren.

Those of us who had the good fortune to work closely with Mr. Clevenger have a deep sense of gratitude and appreciation for the knowledge and help which he gave to us so willingly. We, and his many other friends, mourn his passing.

John Davenport (Member 1916) died April 4, 1953 of a coronary occlusion. Mr. Davenport was president and treasurer of the Franklin Mineral Products Co., Franklin, N. C., a firm he organized in 1926 for the wet grinding of mica. Because his business involved both importing and exporting, he travelled widely abroad. Mr. Davenport was born in Allston, Mass., in 1888. He attended Harvard from 1907 to 1909 and graduated from the Colorado School of Mines in 1912. After graduation he worked for Gross & Draper of Denver, before going to work for the Mexican Candelaria Co. in Durango. Among other companies, he worked for Wausau Abrasives in Wisconsin and the Rhodelite Co. in Willits, N. C. He was a member of the National Assn. of Manufacturers. In recent years Mr. Davenport had made his home in Brighton, Mass.

Harry J. Evans (Member 1944) died June 1, 1953 of a heart attack. He mined in many countries and in 1950 completed an account of his mining experiences, but the manuscript was unfortunately lost in the Korean evacuation. Mr. Evans was born in 1888 in Oregon City, Ore., and graduated from Oregon State College in 1910. His early experience was gained in mining districts of Oregon and Idaho. He first went to Korea in 1913. He returned there in 1916 to be chief engineer for the Oriental Consolidated Mining Co., a New York corporation operating a large gold mining concession. Later he was employed by the Cortez Consolidated Silver Mines in Nevada, the Phelps Dodge Corp. in Arizona, and the Cia. Minera Nazareno y Catasillas in Mexico. In 1943 he was a mineral specialist for FEA in Washington, D. C., and his investigations for and supervision of the strategic mineral programs took him to Brazil and Nigeria. Mr. Evans was later a technical consultant to the Senate Mining and Minerals Industry Sub-Committee.

Charles S. T. Farish (Member 1920) died Aug. 29, 1953 in an automobile accident while returning to his home in Albuquerque, N. Mex., from El Paso. Mr. Farish was connected with the Cerro de Pasco Copper Corp. in Peru for over 30 years. Before his retirement in 1951 he was general superintendent of mines and operations. Mr. Farish was born in Denver in 1888. He was the son of William A. Farish and a nephew of John B. Farish, both noted engineers of early day Colorado. His first position after graduating from Michigan College of Mines in 1912 was as an engineer and assayer for Black Bear Mine, Siskiyou County, Calif. After working for six years for Arizona Copper Co. in Metcalf, he went to Peru to work for Soc. Minera Backus y Johnston, a Cerro de Pasco subsidiary. Later he worked for a short period as assistant superintendent for Amparo Mining Co., Jalisco, Mexico, and returned to Peru in 1921. Among many other things at Cerro de Pasco, Mr. Farish will be remembered for the driving of the Mahr tunnel.

Harry P. Henderson (Member 1904) died Sept. 19, 1953 in Concord, Mass. Mr. Henderson was a consulting mining engineer and president of Texas Mining & Smelting Co., Laredo, Texas. He was born in Peabody, Mass., in 1879, and received his A.B. from Harvard in 1901, his S.M. in 1902. After a year as an instructor at Harvard in mining, he began as an assistant surveyor and assayer and rose to be superintendent of Tonopah Development Co. and general superintendent for Goldfield

Consolidated Mines. In 1910 he opened his office in New York as consulting engineer. During World War I Mr. Henderson was with the U.S. Shipping Board and during World War II he was section chief of antimony and beryllium on the War Production Board.

A. R. Llewellyn (Member 1946) died May 14, 1953. He was chief mining engineer for Rochester & Pittsburgh Coal Co., Indiana, Pa., and had been with R & P since 1923. Mr. Llewellyn was born in Ashland, Pa., in 1895 and after graduating from Girard College in Philadelphia in 1912 worked for the Lehigh Valley Coal Co., Centralia, Pa. He later worked for H. C. Frick Coke Co., Scottdale, Pa.; for Andrew Crichton Co., Johnstown, Pa.; and for Emmons Coal Mining Co., Philadelphia, where he was superintendent of the Greenwich mine.

Allan Early MacArthur (Member 1919) died Aug. 16, 1953 as the result of a stroke. He was an instructor of vocational mining in Nucla High School, Nucla, Colo. A born teacher, Mr. MacArthur often said, "I don't teach subjects. I teach kids." Born in 1889 in Salt Lake City, he studied at Worcester Polytechnic Institute and the University of Colorado. Mr. MacArthur graduated from Colorado with the first degree ever given in Industrial Education. Upon leaving the university he was employed by American Smelting & Refining Co. from 1912 to 1921 in the Garfield, Leadville, Durango, and Pueblo plants as a mechanical research worker, foreman, chemist, and engineer. He also worked for Tonopah Extension Mining Co., Annie Laurie Mining Co., and Miami Copper Co. He did industrial training in Wisconsin, Nebraska, and Colorado. The mining program he taught in Nucla High School is said to have been the only one of its kind. In his spare time and during the summer, Mr. MacArthur trained men in the uranium mines in the Four Corners country.

Samuel Craig Sandusky (Member 1936) died July 24, 1953. Until his retirement in 1951, Mr. Sandusky had been with the National Lead Co., St. Louis Smelting & Refining Div., for over 25 years as engineer, chief engineer, mine superintendent, superintendent, and general superintendent. For the last two years he was resident agent. Born in Salida, Colo., in 1886, he graduated from the Colorado School of Mines in 1908. Before serving in World War I as a first lieutenant with the Engineers, Mr. Sandusky was a mining engineer with Gemini Mining Co., Eureka, Utah.

Louis A. Scholl, Jr., (Member 1916) died Sept. 22, 1953 in Houston, Texas, after a long illness. Mr. Scholl was chief geologist for the Texas Co. He was born in Pittsburgh in 1887 and graduated from Carnegie Institute of Technology and the School of Mines at Columbia University. He worked briefly with the Candor Mines Co. in North Carolina and with the U.S. Bureau of Mines where he was the co-author of several bulletins on the explosibility of coal dust. He joined the Texas Co. as a field geologist in 1916, and from 1920 until 1925 served in Venezuela. After a year of study at the University of California, he became a consulting geologist and in 1928 was made chief of the geophysical div. Mr. Scholl was a member of the American Assn. of Geologists.

William Huff Wagner (Member 1914) died Aug. 31, 1953 after a brief illness. He was a Washington, D. C., geologist and consulting engineer. Mr. Wagner was born in 1888 in Pottsgrove, Pa. Summers while at the Carnegie Institute of Technology he worked as a rodman, surveyor, and chemist, and after graduating in 1912 with a B.S. in mining engineering, went to Cuba to work for the Spanish American Iron Co. He was later superintendent of The Barrett Co., Johnstown, Pa., chief engineer and geologist for North Butte Mining Co., and valuation engineer for the U.S. Bureau of Internal Revenue. Entering private practice in 1921, he was a consultant on development and operations of mining properties in the U.S., Canada, and Mexico. Mr. Wagner was a vice president and director of Cortez Explorations Ltd., Toronto.

Appreciation of
Lewis Webster Wickes
by Harvey S. Mudd

Lewis Webster Wickes (Member 1902) died at his home in Los Angeles on Sept. 16, 1953. Born at Low Moor, Va. on Aug. 11, 1877, he spent his boyhood days with his parents in Montana at the mining camps of Wickes and Corbin. His mining engineering education was obtained at Massachusetts Institute of Technology, Colorado School of Mines, and Columbia University from which institutions he had degrees of Engineer of Mines and Metallurgical Engineer. He was a member of Phi Kappa Psi. On Feb. 17, 1907 at Ely, Nev., he married Grace Ford. A daughter, Mrs. N. J. Snellenburg of Philadelphia and a grandson, Jonathan, survive.

His early training was varied and broad. He was surveyor and assayer at mines in Colorado and Montana, chemist at the Anaconda Smelter, head chemist at the East Helena plant of American Smelting & Refining Company, field engineer with the U. S. Geological Survey, American Smelting & Refining Co., Gunn-Thompson Co., superintendent of Cumberland Ely Copper Mine and Ely Utah Copper Co. and manager of Nevada Utah Mining & Smelting Co.

During 1905, additional financing for Utah Copper Co. was being sought by Messrs. Penrose and McNeil of Colorado Springs who prior to that time and under the direction of Daniel C. Jackling had carried the burden. Negotiations were carried on with Guggenheim Exploration Co. which undertook a thorough examination of the mine, in the sampling program of which Webster Wickes assisted as the analyst. Following this examination in late 1905, Wickes went to work for George Gunn and W. B. Thompson who were acquiring properties and water rights at Ely, Nev., which later were to be incorporated into the Nevada Consolidated Copper Co.

Wickes had become engineer in the office of Seeley W. Mudd and Philip Wiseman before World War I. Following the war, in which Wickes served as major of U. S. Engineers in France for two years, he returned to the organization. After discharge from the Army, in which for many years he continued his interest, he inspected the property of the Cyprus Mines Corp., discovered in 1913 by Charles Godfrey Gunther, and also investigated other properties in Southern Europe and the Near East.

During his association with the Mudd-Wiseman group, Wickes examined many mining properties in the western states and Mexico. This association continued to his death and he served faithfully, honestly, fearlessly, in an advisory capacity on many projects and problems, as treasurer of Cactus Mines, as treasurer and director of Cyprus Mines Corp. He was well acquainted with the petroleum industry.

He was a Legion of Honor Member of the AIME, member of the Mining & Metallurgical Society of America, of the Society of American Military Engineers; the American Petroleum Institute, University Club of Los Angeles, the Masonic Order, the Shrine.

His counsel was highly valued by his associates; he was beloved for his keen sense of humor, his forthrightness, his sincerity, his high sense of loyalty to friends and profession and the thoroughness with which he pursued his business and his hobbies. He will be sorely missed.

NECROLOGY

Date Elected	Name	Date of Death
1913	Edson S. Bastin	Oct. 9, 1953
1920	C. F. Bowen	Unknown
1921	M. G. Cheney	Sept. 28, 1953
1948	B. C. Colcord	Aug. 16, 1953
1899	Robert J. Grant	Unknown
1945	Frederick Ernest Hall	Oct. 19, 1953
1905	C. E. Julihn	Aug. 8, 1953
1940	T. S. McDougal	Mar. 28, 1953
1941	Robert L. McLaren	June 29, 1953
1918	B. C. Osler	March 1952
1947	Richard W. Parsons	Oct. 5, 1953
1946	J. C. S. Reynolds	Unknown
1896	H. C. P. Woolmer	Oct. 11, 1953

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on October 31, 1953 was 19,503; in addition 1838 Student Associates were enrolled.

ADMISSIONS COMMITTEE

O. B. J. Fraser, Chairman; Philip D. Wilson, Vice-Chairman; F. A. Ayer, A. C. Brinker, R. H. Dickson, Max Gensamer, Ivan A. Given, Fred W. Hanson, T. D. Jones, George N. Lutjen, E. A. Prentis, Sidney Rolle, John T. Sherman, Frank T. Sisco, R. L. Ziegfeld.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Trussville—Vann, Robert King, Jr. (J)

Arizona
Morenci—Hewitt, Robert S. (C/S—A-M)
Portal—Brittain, Richard L. (M)
Tucson—Beech, Charles S. (R. M)

Arkansas
Waldron—Mizelle, E. P. (M)

California
Darwin—Arlin, Zana E. (J)

Colorado
Gilman—Fessenden, Paul H. (J)

Idaho
Kellogg—Kirkpatrick, Kenneth K. (M)
Kellogg—Wilson, John H., Jr. (M)

Illinois
Chicago—Bouwer, Sidney C. (M)
Chicago—Manley, Paul C. (R. C/S—A-M)
Chicago—Uzelac, Joe G. (R. C/S—S-J)
Collinsville—Bell, Gordon M. (C/S—J-M)

Michigan
Detroit—Hovsepian, Abraham (M)
Houghton—Greenwood, Robert (M)
Ishpeming—Poll, Jay A. (C/S—J-M)

New Jersey
Metuchen—Porter, Carroll B. (M)

New York
Mayville—Weaver, Fred L. (M)

North Carolina
Henderson—O'Donnell, John C. (M)

Ohio
Galion—Foreman, William E. (J)

Pennsylvania
Belle Vernon—Montgomery, Charles R. (M)
Blue Bell—Weaver, William M., Jr. (M)
Pittsburgh—Ireland, Melville H. (M)
State College—Decker, Robert G. (J)

Tennessee
Kingsport—Kneass, George B., Jr. (J)

Texas
Randolph Air Force Base—Gallemore, Willard A. (R. M)

Utah
Salt Lake City—O'Keefe, John P. (A)
Salt Lake City—Vaughn, George G. (A)

Virginia
Roanoke—Ilyus, E. Burwell (M)

West Virginia
Huntington—Lilly, James R. (J)

Africa
British East Africa, Nairobi, Kenya—Furst, John (J)
So. West Africa, Abenab-via Grootfontein—Lombard, Frans L. (J)

Australia
Queensland, Cloncurry—Marks, Harry (M)

Canada
Kimberly, B.C.—Bloomer, Percy T. (M)
Atikokan, Ont.—Kipnis, Norman (A)
Toronto, Ont.—Parr, Theo M. (A)

Ceylon
Kotiyakumbura—Diamond, Pallewatte K. (A)

France
Seine-et-Oise—Mabile, Jacques G. (M)

Mexico
Chihuahua—Astiazaran, Antonio R. (R. C/S—S-J)
Fresnillo—McMillan, Donald T. (R. C/S—J-M)

—Coming Events—

Dec. 11, AIME, St. Louis Section, York Hotel, St. Louis.

Dec. 13-16, American Institute of Chemical Engineers, Annual Meeting, Hotel Jefferson, St. Louis.

Dec. 27, Conference on Scientific Editorial Problems, AAAS, Boston.

Dec. 28-29, Annual Chemical Engineering Symposium, University of Michigan, Ann Arbor.

Jan. 6, 1954, AIME, Chicago Local Section, Chicago.

Jan. 8, AIME, St. Louis Local Section, York Hotel, St. Louis.

Jan. 12-14, National Constructors Assn., Annual Meeting, Hotel Commodore, New York.

Jan. 13, AIME, Connecticut Local Section, American Brass Co., Torrington, Conn.

Jan. 13, AIME, Bessemer Committee, Annual Meeting, Duquesne Club, Pittsburgh.

Jan. 20, AIME National Open Hearth Steel Committee, Western Section, Rodger Young Auditorium, Los Angeles.

Jan. 25-27, Plant Maintenance & Engineering Conference, Hotel Conrad Hilton, Chicago.

Jan. 25-28, Plant Maintenance & Engineering Show, International Amphitheatre, Chicago.

Feb. 1-3, Fifth Annual Southeastern Symposium on Industrial Instrumentation, Engineering & Industries Bldg., Gainesville, Fla. Instrument Society of America.

Feb. 2, AIME, Chicago Local Section, Chicago Bar Assn., Chicago.

Feb. 15-18, AIME, Annual Meeting, Mining and Petroleum Branches, Hotel Statler; Metals Branch, Hotel McAlpin, New York.

Mar. 3, AIME, Chicago Local Section, Chicago Bar Assn., Chicago.

Mar. 8-10, American Institute of Chemical Engineers, Statler Hotel, Washington, D. C.

Mar. 10, AIME, Connecticut Local Section, American Brass Co., Torrington, Conn.

Mar. 15-19, National Assn. of Corrosion Engineers, Municipal Auditorium, Kansas City.

Mar. 17, AIME, National Open Hearth Steel Committee, Western Section, Rodger Young Auditorium, Los Angeles.

Apr. 5-7, AIME, Blast Furnace, Coke Oven, Raw Materials, and National Open Hearth Conference, Palmer House, Chicago.

Apr. 7, AIME, Chicago Local Section, Chicago Bar Assn., Chicago.

Apr. 26-28, Canadian Institute of Mining and Metallurgy, Annual Meeting, Mount Royal Hotel, Montreal.

Apr. 26-30, American Society of Tool Engineers' Industrial Exposition, Convention Center, Philadelphia.

Apr. 27, Open Meeting of the Assn. of Consulting Chemists and Chemical Engineers Inc., Hotel Belmont Plaza, New York.

Apr. 30-May 1, Pacific Northwest Metals and Minerals Conference of 1954, joint meeting of Metals Branch and Industrial Minerals Div., Portland, Ore.

May 2-6, Electrochemical Society, La Salle Hotel, Chicago.

May 3-5, Coal Convention of the American Mining Congress, Cincinnati.

May 3-8, International Conference on Complete Gasification of Coal, Inichar, Liége, Belgium.

May 8-14, American Foundrymen's Society, Cleveland Auditorium, Cleveland.

Sept. 23-24, AIME Minerals Beneficiation Div., Fall Meeting, San Francisco.

Oct. 5-9, AIME Industrial Minerals Div., Fall Meeting, Whiteface Inn, Lake Placid, N. Y.

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James J. McMahon, Inc.

Anaconda Copper Mining Co. ... *
Kenyon & Eckhardt Inc.

Armour & Co. ... 1163
Foote, Cone & Belding

Aros Electric, Inc. ... 1182

Atlas Car & Mfg. Co. ... 1194
Howson Adv.

Bartlett & Snow Co., The C. O. ... 1307
Henry T. Bourne Adv.

Bihdsboro Steel Fdy. & Machine Co. ... 1301
Beaumont, Heller & Sperling Inc.

Carborundum Co. ... 1296, 1297
G. M. Basford Co.

Card Iron Works ... 1298
Gray and Co., Inc.

Chain Belt Co. ... 1173
The Buchen Co.

Chester Cable Corp. ... *
George Homer Martin Associates

Chicago Pneumatic Tool Co. ... 1199
G. M. Basford Co.

Christensen Diamond Products Co. ... *
Axelsen, Bennett & Clark, Inc.

Colorado Fuel & Iron Corp. ... 1170
Doyle, Kitchen & McCormick, Inc.

Colorado Iron Works Co. ... 1160, 1161
Walter L. Schump, Advertising

Copco Pacific, Ltd. ... 1186
Sturges and Assoc.

Deister Concentrator Co. ... 1148
Louis B. Wade, Inc.

Denver Equipment Co. ... 1198
Bill Bonsib Adv.

Detroit Diesel Engine Div. ... 1164
Kudner Agency, Inc.

Dings Magnetic Separator Co. ... *
Russell T. Gray, Inc.

Dorr Co., The ... 1149, 1200
Sutherland-Abbott Adv.

Dow Chemical Co., The ... 1184
MacManus, John & Adams, Inc.

Eimco Corp., The ... 1153, 1202
Matsie Co.

Electric Controller & Mfg. Co. ... 1168, 1169
The Bayless-Kerr Co.

Electric Machinery Mfg. Co. ... 1306
The Alfred Colle Co.

Gardner-Denver Co. ... 1176
The Buchen Co.

General Electric Co. ... 1156, 1157
G. M. Basford Co.

Greensburg Machine Co. ... 1175
McHenry-Derek Adv.

Hardinge Co., Inc. ... 1195
The W. H. Long Co.

Harnischfeger Corp. ... *
The Buchen Co.

Hercules Powder Co. (Explosives) ... 1197
Fuller & Smith & Ross, Inc.

Hercules Powder Co. (Flotation) ... 1152
Fuller & Smith & Ross, Inc.

Hewitt-Robins, Inc. ... *
Fuller & Smith & Ross, Inc.

Heyl & Patterson, Inc. ... 1154
Dan A. Sullivan Adv.

Humphreys Investment Co. ... 1166
Ed M. Hunter & Co.

Ingersoll-Rand Co. ... 1150, 1151
Rickard & Co.

Instruments, Inc. ... *
Louis A. Brandenburg Adv.

International Nickel Co., Inc. ... 1180
Marschalk & Pratt Co.

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F. P. Walther, Jr., and Assoc.

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Walker & Downing

Lake Shore Engineering Co. ... 1178
Russell T. Gray, Inc.

Le Roi Co. ... 1158, 1159
Hoffman & York, Inc.

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Andrews Agency Inc.

Longyear Co., E. J. ... 1165
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E. M. Freystadt Assoc.

Magor Car Corp. ... 1172
Bauer Adv. Inc.

Mancha Storage Battery Locomotive, Div. Goodman Mfg. Co. ... 1187
L. H. Gross and Associates

McKiernan-Terry Corp. ... 1196
Michel-Cather, Inc.

Mine & Smelter Supply Co. ... 1160, 1161
Walter L. Schump, Advertising

Mine Safety Appliances Co. ... Fourth Cover
Ketchum, MacLeod & Grove, Inc.

Morse Bros. Machinery Co. ... *
Max Goldberg Adv. Agency

Mosser & Son, W. F. ... 1314

National Tank & Pipe Co. ... *
Joseph R. Gerber Co.

Nordberg Mfg. Co. ... 1179
Russell T. Gray, Inc.

Oliver United Filters Inc. ... 1310, 1311
Sanger-Funnell, Inc.

Pennsylvania Transformer Co. ... 1174

Phelps Dodge Refining Co. ... 1302
The House of J. Hayden Twiss

Research Corp. ... 1304
Michel-Cather, Inc.

Ruska Instrument Co. ... *
Brennan Adv.

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Symonds, MacKenzie & Co.

Sheffield Steel Co. ... *
R. J. Potts-Calkins & Holden Adv.

Smidth & Co., F. L. ... 1300
The Stuart Co.

Smit & Co., Inc., Anton ... 1315
J. Gerald Brown Adv.

Sprague & Henwood, Inc. ... 1177
Frederick B. Garrahan Adv.

Stearns Magnetic, Inc. ... *
Eldred Vetter Agency

Stearns-Roger Mfg. Co. ... 1171
Gray & Co., Inc.

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Sanger-Funnell, Inc.

Tyler Co., W. S. ... 1315

U. S. Steel Co. ... *
Columbia-Geneva Steel Div.
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Vulcan Iron Works ... 1292, 1293
Anthracite Adv.

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